DEVELOPMENT PLAN NORMAN WELLS, N.W.T.

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NORMAN WELLS, N.W.T.

Prepared by

W.J. Francl & Associates
Consulting Engineering Ltd.,

for the

Government of the

Northwest Territories

June 1974

Canada

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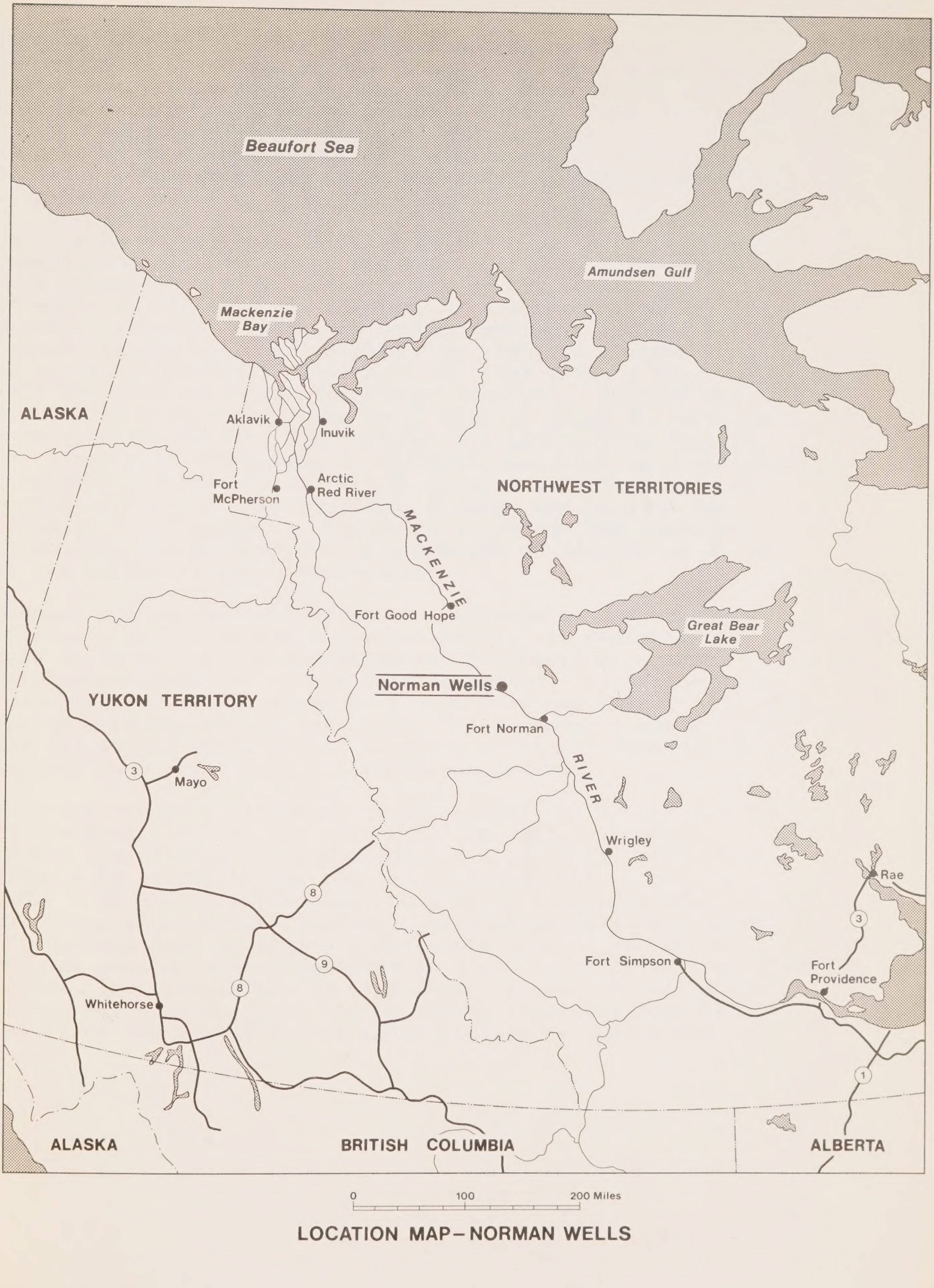
This report is advisory to the N.W.T. Government, it is not final and will be subject to review with the community council. All dollar figures contained in the report are subject to normal financial constraints.



LOCATION MAP—NORMAN WELLS

RÉSUMÉ EN FRANÇAIS

Ce rapport contient le plan d'aménagement proposé pour l'agglomération de Norman Wells, T.N.-O. L'auteur y expose certaines caractéristiques de la localité et en décrit les dimensions futures et l'aspect physique. On y trouve également des constations et des conclusions relatives à la croissance et au développement de l'agglomération par suite de certains travaux de mise en valeur exécutés présentement dans le Nord.

L'histoire de Norman Wells diffère de celle de la plupart des agglomérations plus anciennes des Territoires du Nord-Ouest. Au tout début, ce n'était pas un poste de traite et, par conséquent, il n'y avait ni mission, ni détachement de la Gendarmerie royale, ni services gouvernementaux. Norman Wells a d'abord été une ville pétrolière. En 1920, la société Imperial Oil y découvrit du pétrole et, plus tard, y construisit une raffinerie qui fonctionne toujours. Aujourd'hui la population change par suite de la mise en place de services et à cause d'autres activités reliées à l'exploration dans le Nord. L'activité économique va sûrement continuer de s'accroître dans le Nord. Norman Wells, située au milieu de la vallée du Mackenzie, a donc un rôle important à jouer sur le plan des services et des transports, notamment en raison des travaux qui découlent des découvertes de gisements de pétrole et de gaz ainsi que des activités d'exploration.

Ce rapport expose les antécédents économiques qui constituent les facteurs de croissance de Norman Wells. Il renferme une analyse de la croissance démographique à prévoir en raison de circonstances et des divers développements. Il évalue les besoins d'espace physique de l'agglomération afin d'atteindre la croissance envisagée. Finalement, l'auteur étudie les autres types d'agglomération qu'il est possible d'aménager pour faire face à l'expansion prévue.

Étant donné que le lotissement urbain actuel, borné par le fleuve Mackenzie et par les installations déjà existantes, se trouve limité dans son expansion, et à cause des piètres conditions de terrain de la région, il était évident que le choix d'un nouvel emplacement pour cette agglomération devrait être sérieusement étudié. Des photographies aériennes ont été prises dans la région avoisinante afin de déterminer toutes les possibilités d'emplacement d'une nouvelle agglomération. Parmi les lieux possibles, on en a choisi un qui offrait la meilleure solution du point de vue accès, avantages pour le transport et les installations industrielles et conditions

propices de terrain. Des études préalables du sol ont alors été faites et elles ont confirmé le fait que l'endroit se prête à l'aménagement d'une nouvelle agglomération.

L'auteur propose trois autres plans d'aménagement dont deux sont basés sur l'aménagement complet du lotissement urbain actuel avec des possibilités de débordement dans une nouvelle région ou dans la région où se trouve actuellement l'aéroport, le troisième propose l'aménagement immédiat d'un nouvel emplacement. Il expose les avantages et les inconvénients de chaque plan et il décrit les modes possibles de développement. Pour chque éventualité, il présente un programme d'aménagement et en indique le coût approximatif. Pour chacun des plans, il fournit également des prévisions qui illustrent l'ampleur des dépenses à engager jusqu'en 1983 pour exécuter le programme d'aménagement, quel que soit le plan adopté.

En conclusion, l'auteur estime que le plan le plus avantageux pour assurer l'aménagement et l'expansion soutenus de Norman Wells consiste à orienter le développement résidentiel et secondaire de l'agglomération vers un autre emplacement. Celui-ci présentera des avantages esthétiques, fera le raccordement avec la route et sera protégé de toutes interférence aérienne. Il y aura assez d'espace pour une expansion illimitée, et l'aménagement pourra être planifié de manière à établir des relations convenables entre ses diverses parties.

Comme Norman Wells est une agglomération relativement jeune avec une population assez nouvelle, on n'y est pas très attaché à l'emplacement actuel du lotissement urbain. Puisque la plupart des terres et des édifices sont sous le contrôle du gouvernement, il y aura peu de problèmes à se déplacer vers un nouvel endroit. Les services d'eau et d'égoût devraient être installés dans une zone qui procurera des espaces suffisants pour une expansion ultérieure. La zone actuellement occupée par des bâtiments résidentiels serait plus propice à l'établissement d'industries légères, et les installations déjà existantes en faciliteraient grandement la vente.

Grâce aux meilleures conditions du sol offertes par le nouvel emplacement proposé, des bâtiments, des rues et des services pourraient être construits au meilleur prix possible. Le plan proposé permettrait l'aménagement voulu pour faire face à l'expansion probable des vingt prochaines années au coût le plus bas, soit environ $13,000,000 (coût de juin 1974).

Enfin, l'auteur recommande l'exécution prochaine, au nouvel emplacement, d'études techniques, de relevés topographiques et d'études détaillées du sol afin de mieux définir sa situation et d'établir des paramètres. La planification et la conception des services et des rues devraient être entreprises le plus tôt possible; la construction selon un calendrier permettrait d'occuper les premiers bâtiments au plus tard en 1976.

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I. INTRODUCTION

This report presents the proposed Development Plan for the community of Norman Wells, N.W.T.

Terms of reference for the report, established in July, 1973 by the Government of the Northwest Territories, Department of Local Government, are included in Appendix A. The work was done in association with Makale, Holloway and Associates Ltd., Town and Regional Planning Consultants.

This report deals with the future size and physical form of Norman Wells and with certain aspects of the present community. It presents our findings and conclusions on the growth and development of the community as a result of specific resource-related developments now occurring in the north. The report covers several basic items:

1. Economic background which establishes the factors stimulating the growth of the community.
2. Population analysis indicating the various levels of growth anticipated in connection with individual developments and circumstances.
3. Existing conditions and recommendations for improvements.
4. The physical space requirements of the community to accommodate the expected growth.
5. The alternative forms of community which may be considered in order to cope with the expected growth.
6. Implications of adopting each alternative for development of the community.
7. Proposed design concepts for several alternative areas of growth.

Because of the unique situation at Norman Wells, where physical limitations of the existing townsite impose restrictions on the ultimate size of the community in its present location, it was necessary to consider several alternative forms for the community. The pros and cons of each of these alternatives have been presented, and an order-of-magnitude cost comparison has been made.

After full consideration of all factors involved, the most favourable plan for the continued development of Norman Wells has been selected and its adoption and implementation recommended.

II. PREVIOUS STUDY WORK

In this study, efforts were made to avoid duplication of study work done by others, except as appeared necessary due to changed conditions or requirements. Previous work is catalogued here for the purpose of providing specific references and background to the current study.

1. 1970: "Permafrost in Canada, Its Influence on Northern Development", (Roger J.E. Brown, published by University of Toronto Press.) A comprehensive analysis of permafrost - its origin, definition and occurrence. Includes a review of existing conditions and past experience at Norman Wells.

2. 1970: "Planning Report and Development Plan, Norman Wells, N.W.T.", (Makale, Holloway and Associates Ltd.) This study analyzed the existing community in 1970, with emphasis on its physical form and the improvements needed. The report presented a short range plan for reorganizing and consolidating the development of the community.

3. 1970: "Engineering Report on Norman Wells, N.W.T.", (Associated Engineering Services Ltd.) This report was intended to complement the Planning Report by Makale, Holloway and Associates. Its purpose was to develop a short and long range plan for the settlement from an engineering point of view and to set priorities on the program.

4. 1972: "Supplement to 1970 Report on Norman Wells", (Associated Engineering Services Ltd.) This report was intended to update and expand upon the previous engineering report of 1970.

5. 1973: "Report on Engineering Study of Sewage Disposal Facilities at Norman Wells, N.W.T., (W.J. Francl and Associates Consulting Engineering Ltd., for Environment Canada). This report presented an analysis of the feasibility of a sewage disposal system, with construction recommendations, cost estimates, and methods of cost apportionment.

6. 1973: "Solid Waste Management in the Canadian North", (Stanley Associates Engineering Ltd., for Environment Canada). This report and the two which follow are part of a program of the Solid Waste Management Division of

6. 1973: (continued)

Environment Canada of inviting selected consultants to identify possible approaches to collection and disposal of solid waste in the north.

7. 1973: "Solid Waste Management in the Canadian North", (Underwood, McLellan and Associates Ltd., for Environment Canada).

8. 1973: "Solid Waste Disposal in Communities of the Northwest Territories", (University of Toronto, Department of Civil Engineering, for Environment Canada).

9. 1973: "Granular Materials Inventory, Norman Wells, N.W.T., Community Study Area", (PEMCAN Services "72", for Department of Indian Affairs and Northern Development). An investigation of the availability of granular material deposits within a ten mile radius of Norman Wells.

10. 1973: "Mackenzie Valley Social Impact Study", (Gemini North Ltd.). A study on the effects upon communities within the area of influence of proposed and predicted developments concerning oil and gas related activities, including pipelines, in the Mackenzie region. This study examined the impact of proposed development in the Mackenzie Valley on the settlement of Norman Wells, and included population growth projections for the settlement to 1980.

11. 1974: "Report on Engineering Study, Land Fill Project, Norman Wells, N.W.T.", (Department of Public Works of Canada, Western Region, Design and Construction Branch). A study on the estimated cost of developing the proposed extension of the settlement of Norman Wells by utilizing material from hydraulic dredging in the Mackenzie River, and the alternative cost of filling from conventional borrow sources.

III. ECONOMIC BASE

Norman Wells has a different historical background to most longer-established communities in the Northwest Territories; it was not started as a trading post and thus such elements as a mission, R.C.M.P. detachment and government services were formerly lacking. Rather, the community started as predominantly a company town. In 1920 Imperial Oil discovered oil in this location and later established a refinery which still operates today. The composition of the population is now changing through the establishment of services and other activities related to northern exploration. The basic activities affecting the growth and future development of Norman Wells are outlined below.

A. FISHING, HUNTING AND TRAPPING

Norman Wells is mainly populated by skilled labour from southern Canada. The native population is very small and thus hunting or fishing is not significant in the community's economy. Some tourists travel to the area and hunt for sport and there are some local guides that will assist these tourists; however, again this is insignificant.

B. OIL AND GAS

The Imperial Oil refinery was established during the Second World War. In 1952 the refinery's production was about 300,000 barrels per year. In 1969 part of the plant was modernized and the capacity increased. Presently production averages 3,000 barrels of crude oil per day or about 1,000,000 barrels of crude per year. The crude oil is light weight and of low viscosity and thus ideal for the cold climate. The majority of production comes from the islands in the river. In the summer the crude is barged across to the refinery and in the winter is piped over the ice; thus during freeze-up and break-up the supply is interrupted.

The products are regular gasoline, jet fuel, northern diesel fuel and some heavy diesel. Most of the products are used to the north (Inuvik) while some heavy oil is sent to Yellowknife and Hay River.

In the last several years, the world energy situation has had an impact on oil and gas exploration. Discoveries made in the Canadian Arctic are now greatly in demand as a result of fuel shortages in North America and elsewhere. After the first Mackenzie Delta discovery, the pace of exploration quickened. Norman Wells is an important transportation centre and base point for many of the exploration firms.

C. TRANSPORTATION SERVICES

An important activity of the community is the provision of transportation services. Presently air and water are the two main modes of transportation. Those two handle many thousands of tons of freight each year and employ a large portion of the population. In addition, a great number of helicopter firms provide transportation for men involved in exploration. The Mackenzie River is presently an important transportation corridor; moreover, the valley is a corridor through which pipelines may be laid in order to carry oil and natural gas to their markets. The construction of gas and oil pipelines will stimulate economic activity around Norman Wells. The Mackenzie Valley is also the route for an all-season highway that is presently being constructed. Norman Wells is the mid-point along the Mackenzie and thus it will have the opportunity to act as a transportation and service centre for activities connected to discoveries of oil and gas, for servicing the pipelines, and for serving the highway. The highway is tentatively schedule for completion by 1978.

Norman Wells will be a centre for road maintenance crews, serving a length of highway fifty miles in each direction from Norman Wells, and employing approximately twenty men. In addition, increased travel and travel services will have to be provided.

Canadian Arctic Gas, a consortium of 28 companies, has carried out extensive studies on the technological and environmental problems of constructing and operating a gas pipeline in the North. They are now satisfied that a natural gas pipeline could be laid in all conditions from Prudhoe Bay to the Mackenzie Valley and south of the Mackenzie Valley corridor into Alberta to a point northwest of Calgary at Caroline. Here it would divide into two with a trunk extending southwest and the other south. The proposed pipeline will comprise more than 2,500 miles of 48-inch pipe as far as Caroline and 42-inch pipe thereafter. The facilities would be capable of delivering 4 billion cubic feet of gas per year. (The Geological Survey of Canada estimates that there are 100 trillion cubic feet of potential reserves in the north available for the pipeline.) The consortium filed an application for construction in early 1974. If construction starts as planned in 1976-77 gas from the Delta could be flowing by 1978-79. The construction labour force is expected to peak at approximately 8,000 men. The line will be probably constructed in 100-mile sections. A crew of approximately 700 men will be required for each section. After construction of the $5 billion project approximately 200 people will be permanently employed in servicing the line in the Northwest Territories. There will be two major centres, one in Fort Simpson, and the other in Inuvik. A third centre at mid-point (which we presume to be Norman Wells) will employ approximately 50 workers.

In addition to the gas reserves there are oil reserves in the Arctic. The timing of an oil pipeline is presently uncertain.

With the great demand for oil and the continuous exploration of the North, however, it is quite possible that an oil pipeline will be constructed in the Mackenzie Valley. The construction and operation of the line should have similar expansionary effects on the economy as the gas pipeline.

Economic activity in the North will evidently greatly increase in the future years. Norman Wells as the mid-point of the Mackenzie Valley thus has the opportunity to act as a transportation and service centre for activities connected to discoveries of oil and gas and other exploratory activities.

IV. POPULATION

The economic base analysis indicated growth in Norman Wells resulting from three major developments, i.e.:

1) The construction and operation of the Mackenzie Highway.

2) The construction and operation of the Canadian Arctic Gas pipeline through the Mackenzie Valley.

3) The construction and operation (at a presently undetermined time in the future) of an oil pipeline from the Mackenzie Delta again running through the Mackenzie Valley.

Norman Wells will assume, therefore, a triple role. The highway will require a major maintenance centre for operation of the highway (which we assume will be Norman Wells) serving at least a 100-mile stretch centred on the settlement. The gas pipeline requires three operational centres in the Mackenzie Valley, one of these in a central location; that centre will most reasonably be Norman Wells. Although no data or other plans are as yet available concerning the construction and operation of the oil pipeline, it is assumed that its characteristics would be similar to those of the gas pipeline requiring similar number of personnel in the operation and maintenance and hence having similar effects on population growth. That population growth again should be centred at Norman Wells.

The present population of the settlement is a little under 450 persons (permanent population) with a transient population in addition of between 50 and 100 persons. In assessing the impact on the community of the developments outlined above, we see the population being within 20 years between four and six times the present level. Our estimates were based on several basic factors:

1) That there would remain in the community a permanent level of population similar to that at present and associated largely with the basic economy of the settlement as it is today, i.e., employment in the Imperial Oil refinery, airport and associated operations, exploratory activities and the service occupations linked to these.

2) That each of the three major developments - the highway, the gas and oil pipelines - would generate a certain level of what we term "basic" employment which would remain in the community after construction operations have ceased.

3) That in turn there would be additional service or "non-basic" employment generated by the additional demands of the basic work force and their dependents.

The addition of all population increments resulting from the above developments resulted in population estimates for each five years' period for the next 20 years. In producing these estimates, we assumed that by 1978 construction of the gas pipeline would be underway and that by the same time the Mackenzie Highway would be operational. We assumed further that by 1983 the pipeline would be fully operational. In the absence of any other information we assumed that the oil pipeline would be under construction by 1988 and would be fully operational by 1993.

We produced two estimates of population in order to assess the impact and the demands created by these activities. The first estimate took into account only the three major developments discussed here. It is apparent, however, that in addition to those developments there will be additional activities in the Norman Wells "region" associated with continued exploration and growing use of the transportation network. Beyond the initial estimates, therefore, we projected an increment of population resulting from these other activities. The resulting population estimates are

presented below. They include both permanent population and estimated transient population which the community must also house and provide with services.

Projected Population 1973 - 1993

1) Low Projection

Year	Permanent Population		Transient Population		Total	% Growth Per 5-Year Period
	No.	%	No.	%		
1973	444	81.6	100	18.4	544	
1978	820	71.4	323		1,143	110.0
1983	1,112	80.4	270		1,382	20.9
1988	1,593	83.2	320		1,913	38.4
1993	1,610	83.4	327		1,937	1.3

2) High Projection

Year	Permanent No.	Permanent %	Transient No.	Transient %	Total	% Growth Per 5-Year Period
1973	444	81,6	100	18.4	544	
1978	1,016		323		1,339	146.1
1983	1,542		270		1,812	35.3
1988	2,334		320		2,654	46.5
1993	2,658		327		2,985	12.5

A more detailed derivation of population growth projections is contained in Appendix B.

V. EXISTING CONDITIONS

A. Land Use

Land uses within the existing community are illustrated on Plate I. Examination of the community revealed certain significant features. The Town is elongated following the Mackenzie River, stretching over a distance of about 3 miles. The settlement is divided physically into three areas by large vacant areas and is linked only by a single major spine road. The area is bounded on the north by the Norman Wells airport and on the west by the Imperial Oil Reserve. The three separate areas are:

I) In the west - the Imperial Oil Refinery and associated residential and ancillary development, including recreation centre, nursing station, company store and church.

2) Approximately in the centre of the settlement - the Ministry of Transport (MOT) housing area with local public and administrative offices, including the RCMP headquarters, CNT offices and the settlement's only public store.

3) The most easterly development contains uses ancillary to the airport operation, but includes semi-permanent housing provided by the motel and a recently-developed mobile home park.

The underdevelopment of the community gives it a generally disheveled appearance and this is contributed to by unmade streets and poor maintenance of some yards. Most houses are well-maintained while yard maintenance varies, most being well cared for.

The pattern of development has several major disadvantages:

1) Excessive travelling distances and hence reliance on vehicular transportation, which is reflected in high vehicle usage. Within the settlement, in mid-1973, there were the following vehicular and associated registrations:

   - 171 operators' licences
   - 8 restricted licences
   - 101 ordinary vehicular registrations
   - 118 commercial vehicles
   - 3 public service vehicles
   - 10 rental vehicles
   - 50 motorcycles, and
   - 12 trailers

2) The scatter of community facilities - recreation, school, administration and health facilities - renders them inconvenient to particular segments of the community.

3) There is no real centre and thus "high density" for the community.

4) The adjacency of the refinery and housing provides an unsatisfactory physical and visual environment for many residents.

5) If continued, this pattern of development could possibly lead to the growth of three subcommunities with no sense of identity with each other or any interdependence.

Arising out of this examination several recommendations can be made for improvement:

1) an attempt should be made to consolidate the community if development is considered on the existing site. This would be done by infilling of the vacant land between communities.

2) Eventually the Imperial Oil housing should be relocated to a more satisfactory environment.

3) Public and social facilities should be centralized to make them conveniently accessible to all residents and to provide a "central core" development to give some sense of identity and place to the settlement (including relocated new community hall).

4) There should be segregation of residential and industrial and other incompatible non-residential land uses to reduce the detrimental effects of these on adjoining housing.

5) The Land Use and Development Controls presented in Appendix I should be adopted and enforced to control all development in the community.

There are several constraints on development of the existing site:

I) The first barrier is the Mackenzie River itself, which means that development must take place either northwards or west and east along its banks.

2) The airport reserve is primarily an ownership barrier. There is need for adequate separation between the area used for aircraft handling and the residential community for the protection and safety of residents and for the minimizing of disturbance from noise. CMHC recommends an area free from development extending 2,000 feet either side of the runway. Within that area no development would be considered for mortgaging purposes. In Norman Wells, however, taking into account local conditions we feel this restriction should not be applicable if development on the present site is justified by other conditions. Firstly, there are fewer flights than would be the case with a major airport, particularly jet aircraft flights, and hence lower noise levels than would otherwise be the case. Secondly, there is extremely limited land available which makes any artificial restrictions on land availibility a matter of serious concern. Thirdly, noise disturbances can be overcome through proper housing insulation.

3) The Imperial Oil reserve and the refinery present a definite physical barrier to the west.

4) Beyond the airport the land slopes away from the river for a distance providing a difficult drainage situation and compounding potential servicing problems.

5) Poor surface soil conditions and poor drainage present local development problems on the existing site.

All of these constraints must be taken into account in the future planning of the community since they do restrict the population and development capacity of the land.

B. Housing Conditions

The previous housing survey consudcted in 1969 showed the following housing provision:

- 45 single-family dwellings
- 10 two-family dwellings
- 5 single quarter dormitories, and miscellaneous living quarters attached to non-residential uses.

By fall of 1973 some changes had taken place in the distribution of housing and there was an increase in the total housing stock. There were a similar number of single-family dwellings but more two-family dwellings and additional mobile homes. The structural conditions of these were revealed by a visual survey and are indicated in the following table and on the Building Conditions plan, Plate 2.

Housing Conditions

			Housing Type					
	All Housing		Single - Family		Two-Family		Mobile Homes	
Structural Condition	No.	%	No.	%	No.	%	No.	%
Good	50	54.9	25	55.6	7	33.3	18	72.0
Fair	35	38.5	17	37.8	12	57.1	6	24.0
Poor	6	6.6	3	6.7	2	9.5	1	4.0
Total	91		45		21		25	

The field survey revealed few problems in terms of the quality of housing. More than half of the housing units are in good condition and capable of relocation. Of the 35 houses in fair condition some may not be suitable for moving and if this is considered should be the subject of more detailed examination. Six houses should be replaced as being substandard. A further survey was carried out in fall of 1973 for the Northwest Territories Housing Corporation and this indicated comparative figures with regard to housing conditions as indicated below.

Housing Conditions	
Good	56
Fair	26
Poor	2

The number of dwellings requiring repairs was estimated to be 29. If all of those dwellings were assumed to be in fair condition and the repairs were carried out then presumably all housing other than the poor dwellings could be made physically capable of being moved. This ignores the economic practicality of moving because of such factors as substantial investment in utilidor systems serving the dwelling.

C. Community Facilities

1. Educational

The existing school plant consists of four portable classrooms linked as one unit. It has three teachers and accommodates grades one through eight. No adult education is available. The school has no gymnasium although one room is used as an activity room. The site itself is inadequate for expansion and is poorly located in relation to much of the community. Although the amount of open land area is not so critical since it is unusable much of the winter, the small area (less than 2.5 acres) does place limits

on its use for outdoor recreation for both school children and the community. The playground is poorly developed and gravelly. It has some basic play equipment - teeter-totter, climbing bar, two slides and swings.

The inadequate physical facilities and the lack of education beyond grade eight cause certain social problems. Many families leave town rather than send their children away to hostels in distant centres for education from grade nine onwards. This precludes the building up of a stable community with a balanced social structure. The lack of building and land area also limits the ability to provide additional programs. The principal need, therefore, is for a new school and larger, better developed school site to provide usable play area. The provision of education for more grades than only up to grade eight should be seriously considered in order to encourage proper community development. The school should be located on a new site more central to the existing community and allowing for possible expansion.

2. Health and Protection

The range of health facilities has declined since 1969. At that time there was a resident doctor and hospital service in the Town. This was taken over by the Federal Department of Health in 1972 and is now merely a nursing station with a staff of two nurses. This provides school clinics, baby clinics and immunization facilities. A doctor visits from Inuvik once monthly, a dentist once each six months and an eye specialist once yearly. Seriously ill or injured are flown out for treatment in Edmonton or Inuvik by scheduled flights or in emergency by charter planes. Police protection is provided by one RCMP constable. In 1972 police protection became permanent year round (previously the officer resided in the Town only part of the year.)

Fire protection - there is no overall protection for the whole Town. Imperial Oil has its own fire system with an old water tanker truck. The Company has three fire crews trained primarily to deal with refinery fires. MOT and Imperial Oil each have their own fire chief and this could lead to a lack of coordination. There is a central control system, however, which is operated automatically or manually from the airport. The two systems rely on volunteer fire brigades. There are trained personnel at the airport - four men, one being fully fire-trained. NCPC has protection within the generating plant for electrical fires. Fire protection is limited by the available water supply.

3. Recreation

Outdoor recreational facilities are poorly developed within the Town. In the MOT housing area there is a small children's playground with a sandy surface and with minimal equipment - climbing bars, teeter-totter, slide and sand pit. The school grounds provide some children's play equipment but it is generally a poorly surfaced gravelly area unsuitable for children's play. The major facilities are located in the Imperial Oil area - a curling rink and recreational building (which was to be closed in late 1973) a tennis court and volleyball court, and some open space. There is also a children's playground with two slides, two teeter-totters, climbing bars, swings, merry-go-round, and two sand pits. A new community hall has been built north of the spine road north of the MOT area. This cost approximately $90,000 to $100,000 with the townspeople donating labour and materials. Imperial Oil Ltd. gave $5,000 for the community hall and donated the games room which was to be joined to the new community hall for possible use as a community library or meeting room. A range of activities is available, including curling, badminton, movies (twice weekly), cross-country skiing, and a dance bi-weekly.

There is a need to develop better recreational facilities more centrally located for access to the bulk of the community. These could most satisfactorily be developed in conjunction with the school play fields.

D. Status of Local Government

Norman Wells is primarily dependent on the senior governments for its financing of day-to-day operations and capital development. In our examination of the community we anticipate that the settlement will develop as a sizable community with a fairly broad economic base. As such a community, Norman Wells should have more control over its own destiny and over its own development. We recommend, therefore, that the settlement be incorporated as an independent municipality.

Recently the settlement was assessed but as yet there is no history of local taxation on the assessment base. In view of that, and also in view of the substantial growth anticipated, it is impracticable to assess the future viability of the community in fiscal terms. This could better be done once it is established what physical form the community might take, i.e., which alternative form of development as presented here is adopted. The basic criterion, however, should be to make the community, as far as possible, dependent on local revenues deriving from a broadened and diverse economic and thus assessment base. The achievement of that should form a major factor in the consideration of incorporation.

E. Engineering Analysis of Existing Services and Facilities

1. Water Supply

The existing water supply for the community of Norman Wells is provided by Imperial Oil Ltd. The source of water is a low dam and intake on Bosworth Creek where it passes through the oil refinery complex. The dam consists of steel sheet

piling, backed by rock riprap, combined with a short bridge which crosses the creek at this point to provide access to oil wells and facilities to the northwest. The reservoir behind the dam has a maximum depth of about ten feet and a length of approximately 500 feet, providing minimal storage to allow settlement of sediment.

An intake pipe leads to a wet well in the small pumphouse adjacent to the dam. The service pump, having a capacity of 600 US gallons per minute at 150 foot head at a speed of 2,000 rpm, is powered by a natural gas fueled engine. The pump is presently operated at approximately 1,750 rpm with a discharge volume of 300 to 350 USGPM at 65 psi. A 750 USGPM at 90 psi electric submersible pump in the wet well provides standby capacity. Water treatment facilities, located in the refinery area, consist of two Permutit sand bed pressure filters, rated at 168 USGPM, and gaseous chlorination.

A second intake and pumping facility, located on the Imperial Oil dock in the Mackenzie River, is used to supply process cooling water and water for steam boilers. Thus, the Bosworth Creek supply is used only for domestic purposes. In an emergency condition, or in the event of low water or freezing off of the Bosworth Creek intake, Mackenzie River water can be pumped into the domestic mains.

2. Water Distribution

Water is delivered by Imperial Oil, in a heated above-ground utilidor, to a meter building near the easterly edge of their property. There, the metered water is delivered to the Territorial Government, which owns and operates the utilidor system throughout the rest of the existing community. This

utilidor system has been constructed over a period of time and major portions of it have been recently reconstructed. The newer portions consist of corrugated steel box sections, with the older sections being either wooden box or split corrugated steel culvert.

Most of the structures in the MOT housing area were orginally heated by steam supplied from the Imperial Oil refinery. The utilidors contain steam and condensate return lines which orginally supplied all necessary heat for the utilidors. However, Imperial Oil is desirous of retaining all available steam for their own use and have served notice that the steam supply will eventually be shut off. Thus, most of the houses have been converted to individual oil heat, and the most recent utilidor reconstruction project included installation of a boiler and circulating hot water system for utilidor heating.

3. Sewage Collection and Disposal

Sewage from each of several groups of buildings is collected to one of several septic tanks, each of which discharges its effluent over the river bank into the Mackenzie River. Because of large fluctuations in river level, the effluent is usually exposed on the beach in summer. Sewage collecting lines are run in heated utilidors to prevent freezing. The lack of a unified, efficient sewage treatment facility has resulted in objectionable odours in the community, and the discharge of septic tank effluents to the beaches of the Mackenzie River creates a health hazard. Septic tank discharges are carried along the southerly side of the community by the westward current, and water is drawn directly from this shore by natives for domestic use. The Imperial Oil river intake is also

downstream from most of the septic tanks. Sewage from facilities not serviced by septic tanks or connected to the utilidor system is hauled by a private contractor to the dump near the quarry.

4. Solid Waste

Solid waste, including garbage, paper, trash, car bodies and other rubbish is hauled by a private contractor, by Imperial Oil, by M.O.T., or by individuals to a dump located near the quarry, about 3.5 miles from the community.

5. Electricity

Electricity in Norman Wells is supplied by Northern Canada Power Commission (N.C.P.C.). The powerhouse building is a rigid frame metal building approximately 49 feet by 60 feet. Power is produced by three Caterpillar diesel units of 500 KW, 600 KW and 700 KW capacity, respectively, with a total capacity of 1,800 KW. Fuel storage capacity is 268,000 gallons consisting of one 233,00 gallon tank and one 35,000 gallon tank. The staff of three operates the power plant on a one-shift basis, with an alarm system installed in the residence of one of the operators. The Norman Wells staff is also responsible for maintenance of the N.C.P.C. powerplants at Fort Norman, Fort Franklin and Fort Good Hope which are operated by D.P.W. personnel on contract.

6. Fire Protection

The community of Norman Wells has no unified fire protection facility. Imperial Oil has one fire truck and one small chemical truck for protection of its own property. M.O.T. has a fire truck stationed at the airport for aircraft fire protection. Both of these units are available on call to combat fires in other areas of the community, but there is no coordinating authority and such use is subject to priority calls in their own respective areas.

7. Roads

The few existing roads in the community are generally adequate for the local traffic which they presently carry. The main connecting road parallel to the river, joining the refinery, the town, the airport, and extending easterly to DOT Lake and the transmitter site has been seriously overloaded by heavy truck traffic hauling fill material from the quarry. Except for localized areas of failure, the roads are well maintained and are wide enough for present needs.

8. Topography and Surface Drainage

The bank of the Mackenzie River is relatively straight and steep at the location of Norman Wells, with a height of approximately 40 to 50 feet above the normal river level. From the top of the bank inland for about 800 feet the ground rises slightly, and then dips inland to a wide flat area before rising again to the low airstrip esker approximately one-half mile north of the bank and roughly parallel to it. The low ground approximately 800 feet inland from the bank is flat, poorly drained, and may be classified as muskeg. From the airstrip esker the land further inland dips to another lake and muskeg area. To the west, the area for development is effectively cut off by Bosworth Creek, which meanders in from the Mackenzie Mountains to the north. To the east, the width of the strip of higher ground along the river bank narrows to approximately 400 feet, and thus seriously limits development in that direction.

The present community development is almost entirely located on the narrow strip of higher land along the river bank and drainage is generally adequate, although local problem areas are evident. The remaining underdeveloped areas are low and poorly drained. Two small waterways drain from the low area through the built-up area, and these can be developed to provide the basis

for an adequate drainage system.

9. Soil Types and Permafrost

Surficial mineral-soil materials in the immediate Norman Wells area consist mostly of stratified clayey silt with lesser silty clay and silty fine sand that were deposited in a former glacial lake. The fine-grained glacial-lake sediments are overlain by peat in depressions, varying in depth to as much as 6 to 10 feet. Underlying bedrock, at depths from 15 to 40 feet, is predominately shales and sandstones.

Norman Wells lies within the discontinuous permafrost zone; the mean annual air temperature is 21 degrees F. The ground temperature at a depth of 50 to 100 feet is 26 degrees F., and the permafrost is some 150 to 200 feet thick. Excess ice is common in fine-grained soils and its content usually ranges from thirty to sixty percent.

The active layer thickness under stable vegetation varies from about 2 to 5 feet in well-drained and imperfectly drained fine-grained materials, but it is over 5 feet in sandy deposits. The active layer is about 2 feet or even less thick in dry moss or lichen insulated peatlands. However, the ground is unfrozen in peatlands where there is standing water, or in poorly drained depressions. Unless adequate drainage is provided, ponded waters could cause melting of ground ice and thermal subsidence; in fact, thermal subsidence appears to have occurred in several areas already.

VI. SPACE REQUIREMENTS

The population analysis indicated an eventual community size of between 1,900 and 3,000 persons. Substantial areas of land would be required to accommodate that population and its attendant land use needs in terms of housing, commercial and ancillary developments, public uses and schools and open space. Besides those areas, additional land would be needed also for new industrial development of highway service and commerical development associated with the community's growth. In order to establish the eventual physical size of the community, therefore, we estimated the various land use needs in quantitative terms.

A. Residential

The predonimant form of housing in Norman Wells is single family dwellings. That situation may change, with a gradual trend towards apartments or other forms of multi-family dwellings and mobile homes, owing to several factors:

- The expanding economy may bring an influx of younger married couples not yet ready or unable to purchase single family housing.

- There may be an increasing proportion of the population made up of young single persons and older persons as the community matures.

- Greater mobility of the population, particularily of skilled in-migrants.

- Rising land, building and home-purchasing costs inducing the use of more economical forms of housing.

Greater use of multi-family accommodation and mobile homes would increase the density of development, thus reducing overall land needs. Such increased density may be desirable, particularly if the existing townsite with its limited amount of developable land is further developed. It would enable, also, some measure of

control over the severe climatic conditions. However, northern experience to date indicates, on the part of most residents, a reluctance to accept other than single family housing, at least in the initial stages of community development. For land estimation purposes we assumed a density of development similar to that now current, i.e., 3.5 dwelling units per gross acre. That density will accommodate the new dwellings and their associated facilities - schools, playgrounds, roads and other incidental uses.

The current average household size in single family housing in Norman Wells is 3.89 persons; including single and other related persons would lower that occupancy rate somewhat. However, as the community grows and more facilities become available, we anticipate that the average family size will grow; families are now smaller since many leave the settlement as their children reach high school age. For future projections, therefore, we assume that the average household size will be 4.0 persons. That average was applied also to the transient population since many of those may be housed in shared accommodation, whether in mobile homes, multi-family housing or other transient accommodation. Although the average household size for transient population may, in fact, be lower, thus indicating the need for a greater number of housing units, the density at which those units will be provided will also be higher. There is, therefore, ample flexibility in the land projections to accommodate both the permanent and the transient population. The resulting estimates are presented in the following table:

Residential Land Requirements 1973-1993

1) Low Population Projection

Period	Additional Population	New Units	Additional Acreage
1973 - 78	599	150	42.9
1978 - 83	239	60	17.1
1983 - 88	531	133	38.0
1988 - 93	24	6	1.8
Total	1,393	349	99.8

2) High Population Projection

Period	Additional Population	New Units	Additional Acreage
1973 - 78	795	199	56.9
1978 - 83	473	118	33.7
1983 - 88	842	211	60.3
1988 - 93	331	83	23.7
Total	2,441	611	174.6

The amount of land needed for new residential development over the next twenty years is between 100 and 175 acres, depending on the scale of growth of the community. If the community were relocated land would be needed in addition to house the existing population; that would amount to an additional 39 acres, giving a total requirement of between 139 and 214 acres. In order to allow flexibility in choice of housing location, and to accommodate any unforeseen demand, we added 20% to these estimates, resulting in a total residential land requirement of between 167 and 257 acres for a newly-established community.

B. Commercial

Norman Wells will require commercial development to serve its own permanent residents, the transient population, and visitors and travellers passing through the community. The only reliable segment on which any estimates of commercial demand can be made is the permanent population. The purchasing power of that population will be the primary determinant of retail and associated business growth. Since, however, there is no reliable basis for forecasting the purchasing power of the new population because of so many as yet unknown economic factors, it is more satisfactory to relate commercial growth directly to anticipated population growth. As there will be little if any external trade area population, it is also reasonable to project growth based on the community's population alone.

Anticipated commercial developments may be divided into two classes:

1) "Intensive commercial" uses such as retail stores and offices which generally occupy the central commercial area of a community, and

2) "Service trades" such as service stations and drive-in establishments which use land much less intensively and which may be located on the fringes of the central commercial area or in other unrelated locations.

Our northern research* indicates an average amount of intensive commercial floorspace per person of between 41 and 43 square feet. That appears high in relation to urban centres in southern Canada; however, it is accounted for partly by the greatly increased population for much of the year (transient workers and other visitors), and partly by the absence of any competing centres conveniently accessible in terms of distance, time or cost. For future projections, therefore, we assumed an average of 41 square feet of intensive commercial floorspace per capita of the permanent population. For service trades we assumed an average of 10 square feet per person, similar to that in Hay River in 1969 which then had a similar population to that we anticipate Norman Wells to reach.

The amount of land area for ancillary uses - parking, loading areas, storage, on-site circulation and other incidental uses - we assumed to be provided at a ratio of floorspace to ground area of 1:3.5, similar to the indicated in extensive commercial research in existing urban centres throughout western and northern Canada. For land areas in the service trade sector, where there is more open land in relation to building space, we assumed a ratio of 1:6.0. The resulting estimates are shown in the following table:

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* Collins Bay Townsite - research of space demands in remote communities for establishment of new townsite in Northern Saskatchewan, 1972; and Hay River - examination of existing northern town at population level of 2,000 - 2,500, similar to that expected in Norman Wells.

Commercial Space Needs 1973 -1993

1) Low Population Projection

Period	Retail and Associated		Service Trades	
	Additional Floorspace (sq. ft.)	Additional Land (acs.)	Additional Floorspace (sq. ft.)	Additional Land (acs.)
1973-78*	33,620	2.7	8,200	1.1
1978-83	11,972	1.0	2,920	0.4
1983-88	19,721	1.6	4,810	0.7
1988-93	697	0.1	170	0.1
Total	66,010	5.5	16,100	2.3

2) High Population Projection

Period	Retail and Associated		Service Trades	
	Additional Floorspace (sq. ft.)	Additional Land (acs.)	Additional Floorspace (sq. ft.)	Additional Land (acs.)
1973-78*	41,656	3.3	10,160	1.4
1978-83	21,566	1.7	5,260	0.7
1983-88	32,472	2.6	7,920	1.1
1988-93	13,284	1.1	3,240	0.5
Total	108,978	8.7	26,580	3.7

*Including provision of space for existing population.

By 1993 between 8 and 13 acres of fully-developed commercial space will be required, more than two-thirds of this being within the central commercial area.

C. Schools

Norman Wells has presently school facilities to serve only grades 1 through 8. As the community reaches a more substantial population level, we anticipate that adequate educational facilities will be provided to enhance the settlement's desirability as a place to live and to obviate the enforced out-migration of families seeking higher educational facilities. For future projections, therefore, we assumed school provision for all grades, 1 through 12.

The ratio of resident pupils to population in remote and rapidly developing communities generally averages 300 pupils per 1,000 population.* In Norman Wells, the ratio is 200 per 1,000,but this includes only grades 1 through 8. With the highway operating, and the community's having a more permanent nature, we expect that there will be lesser turnover of population than is now experienced in Norman Wells or other resource communities. For purpose of estimation, therefore, the situation may be assumed to be more similar to that existing in Hay River or other western Canadian centres which vary between 240 and 290 pupils per 1,000 population. The ratio of pupils to population is assumed to be 240 per 1,000; this is low, but allows for a lesser number of school age children associated with the transient segment of the population. The distribution between grades is assumed to be similar to that is other northern or resource communities** as follows:

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*Collins Bay Townsite - research, 1973

**Research for numerous development plans including Collins Bay, Hay River, Yellowknife, Hinton, Peace River.

- Grades 1-6, 66.6% or 160 pupils per 1,000 population
- Grades 7-9, 20.0% or 48 per 1,000
- Grades 10-12, 13.4% or 32 per 1,000

The classroom needs to accommodate the resulting numbers of pupils are estimated at 25 pupils per classroom. The following table indicates the total estimates.

Projected School Population

1) Low Population Projection

	no. of pupils by grades			classrooms by grade***		
	1-6	7-9	10-12	1-6	7-9	10-12
1973*	59	15**	-	2	1	-
1978	131	39	26	6	2	1
1983	178	53	36	8	2	2
1988	255	77	51	10	3	2
1993	258	78	51	10	3	2

2) High Population Projection

	no. of pupils by grades			classrooms by grade***		
	1-6	7-9	10-12	1-6	7-9	10-12
1973*	59	15**	-	2	1	-
1978	163	49	33	7	2	2
1983	247	74	50	10	3	2
1988	373	112	75	15	5	3
1993	425	127	86	19	5	4

* Estimated, N.W.T. Department of Education

** Estimated, N.W.T. Department of Education, grades 7-8 only

*** To nearest one

The estimates indicate that at the higher level of population (3,000 by 1993), the community may require 19 elementary school classrooms and 9 high school (junior and senior high combined). That would demand at least one larger elementary school, or two smaller, and provision for combined junior and senior high school space (since it would be uneconomic and unnecessary to provide separate premises for the small individual classroom demands). In terms of land area, we may apply currently accepted site standards since, despite the limited usefulness of school playfields for much of the year because of weather conditions, space would be required for a range of recreational activities. For elementary school use, a site of between 5 and 7 acres is necessary.

For high schools, the usual needed site area including playfields is between 15 and 20 acres. However, with such a small enrolment, such a size is inessential. Economies in land, buildings and maintenance could be achieved if the elementary and high schools are grouped together in one campus. Under such an arrangement, a further five to seven acres would be adequate to accommodate high school building and open space. Alternatively, the elementary school space could be provided in two smaller schools, built in separate neighbourhoods. That would be preferable, allowing the smaller child to remain in a familiar environment close to home, and maintaining a more "human" scale in school buildings. In that instance, the total school land needs would be between 15 and 21 acres.

D. Public and Quasi-Public

As Norman Wells grows, additional space will be needed for public uses serving the community. These would include administration offices, fire hall, police offices and the like. Most of such space would be provided in conjunction with the central

commercial development. The amount of space required has been estimated based on experience elsewhere* which indicates an average of 5 square feet per capita of floorspace for public and quasi-public uses. The land area estimates assume that incidental space will be provided at a similar ratio to that for commercial developments, i.e. 1:3.5 floorspace to ground area.

The resulting space needs, indicating a land area requirement of less than one acre, are shown in the following table:

Public and Quasi-Public

1) Low Population Projection

Period	Total Floorspace (sq. ft.)	Total Land (acs.)	Additional Floorspace (sq. ft.)	Additional Land (acs.)
1973-1978	4,100	0.3		
1978-1983	5,560	0.5	1,460	0.2
1983-1988	7,965	0.6	2,405	0.1
1988-1993	8,050	0.7	85	0.1
Total			3,950	0.4

2) High Population Projection

Period	Total Floorspace (sq.ft.)	Total Land (acs.)	Additional Floorspace (Sq.ft.)	Additional Land (acs.)
1973-78	5,080	0.4		
1978-83	7,710	0.6	2,630	0.2
1983-88	11,670	0.9	3,960	0.3
1988-93	13,290	1.1	1,620	0.2
Total			8,210	0.7

* Collins Bay Townsite and research in connection with development of plans for Sherwood Park and St. Albert, Alberta.

E. Recreation

The community must provide a range of recreational activities - both indoor and outdoor - to meet varying demands and needs. Some of those, e.g. pool hall or bowling alley, may be provided commercially as part of the central development. However, open land areas will be needed in addition for children's playgrounds, playfields, or park space. These may be provided in conjunction with school development on a joint school-community use basis, or as part of the overall design of residential neighbourhoods.

Commonly accepted standards are usually used to judge the demand or adequacy of open space provision. In the case of Norman Wells, with lengthy winters and severe climatic conditions, this would not be entirely realistic: more reliance may be placed on indoor facilities. However, as evidenced in other larger communities such as Hay River or Yellowknife, there is a need for outdoor recreational space for both active sports and more passive enjoyment. For future planning, therefore, we estimated the potential need based on standards of the Parks and Recreation Association of Canada. According to those, at least one acre of park and recreation space would be needed for every 100 persons. It is recommended that only 25% of that be developed for active recreation. However, the actual use and design of open space areas could be varied in Norman Wells to correspond to actual demand and experience as the community grows. Estimated land needs are shown in the following table:

Recreational Open Space 1973-1993

1) Low Population Projection

	Permanent Population	Land Area (acres)	Additional Acreage
1973	444	4.5	-
1978	820	8.2	3.7
1983	1,112	11.1	2.9
1988	1,593	15.9	4.8
1993	1,610	16.1	0.2

2) High Population Projection

	Permanent Population	Land Area (acres)	Additional Acreage
1973	444	4.5	-
1978	1,016	10.2	5.7
1983	1,542	15.4	5.2
1988	2,334	23.3	7.9
1993	2,658	26.6	3.3

F. Total Community Land Needs

Estimates of land needs for the various ingredients of the community have been made in the previous sections. For the total community (excluding industrial development which is impracticable to predict at this time, and highway commercial which will have specific site demands unrelated to the residential community) the total land needs are summarized below:

TOTAL LAND NEEDS 1973-1993

	Low Population 1993	High Population 1993
Residential*	167 acres	257 acres
Commercial	7.8	12.4
Schools*	15.0	21.0
Public	0.4	0.7
Recreation	16.1	26.6
Total	206.3	317.7

* There is some duplication here since the residential land estimates include space for school sites. However, this allows some margin for additional space needs, e.g. church sites, utility substations, etc.

VII. PROPOSED DESIGN CONCEPTS

A. General

In January 1974 an interm report was submitted which discussed four alternative conceptual forms for future community development. The first alternative was based on the original plan presented by the 1970 Makale, Holloway and Associates report. This plan had severe restrictions in terms of growth and proper community development and its adoption was not reccommended. The last three alternatives discussed in the interim report were capable of accomodating the projected growth in population. With modifications resulting from the review of the interim report,these alternatives formed the bases for the three Design Concepts outlined herein and shown on Plates 3 through 6.

B. Design Concept 1-1A

This concept encompasses the development of the existing site between the airport reserve and the river and east of the Imperial Oil reserve. The basic elements of this design are:

1. Centralized, non-residential uses for optimum access for the community, and including school and recreational area, major commercial development and multi-family housing.
2. The spine road is retained as the major collector road linking the western and eastern parts of the community to each other and to the central area as well as to the industrial employment areas to west and east.

3. Separating the airport and the residential community is an industrial traffic road which would channel heavy traffic from the highway, the airport, and the industrial areas around the community rather than through it, thus minimizing disturbance and danger to residents.
4. To protect the residential area from noise of heavy traffic a treed buffer strip would be retained between the refinery and the community and the industrial traffic road and the community.
5. The capacity of this site is approximately 1,800 persons, which would be increased somewhat by development of multi-family housing.
6. Internal streets are developed within the major road network giving greater privacy and convenience of pedestrian and vehicular movement. They are laid out so as to minimize the lengths of utilidors and the number of street crossings for economical development.

In order to accommodate population growth beyond 1,800 persons an overflow area would have to be provided and this is suggested near to the highway where it is joined by the highway access road. A highway service area for local employment and convenience of the travelling public would be provided adjoining that community. The possible form of community is illustrated on Plate 4. It entails duplicate public facilities, although on a somewhat smaller scale and including school and recreational and commercial areas. The design illustrated could accommodate approximately 1,700 persons, although the size of overflow community could be adjusted and expanded to accommodate whatever population level results from future growth. The trend towards multi-family and mobile home living, which would increase the density of development and thus the capacity of the townsite, was discussed earlier. However

all the proposed design concepts are based on a lower density but using a modular system of subdivision so that areas could be converted to multi-family or mobile home use. Those developments should form part of the permanent residential area with access to all urban facilities.

The relative advantages and disadvantages of this plan are summarized below:

Pros

1. This pattern results in an elongated but still compact community with all major community facilities accessible and convenient to residents.
2. It is a natural rounding off or infilling of the existing community which allows some continuity and use of existing services.
3. There is ready access to the major employment areas - the refinery and the central business district - to the future highway and to the airport.
4. Development in this area may take advantage of views over the river and the surrounding mountains.
5. There is provision for an overflow area to accommodate further population growth beyond the capacity of the existing townsite, planned properly to avoid the creation of a separate community.
6. This pattern makes it possible to channel traffic around rather than through the community.
7. Industry can be well related to the highway access road, to the float plane base and to the airport with ample room available for necessary expansion without constraints or conflicts imposed by adjacent residential development.

Cons

1. Solely residential development of the site will involve relocation of some existing industrial uses and the meteorological station with their attendant costs.
2. Proximity to the airport involves potential noise and crash hazards.
3. The site may have servicing and construction problems.
4. The major employment sources - industrial and highway services must be located somewhat distant, adding to the inconvenience and cost of travelling to and from work.
5. There may be conflicts between industrial development and the airport and its ancillary facilities such as the VOR site.
6. There may be conflicts in traffic movement between the highway and the airport, the refinery and community traffic.
7. Water-related industry may have problems of waterfront access, although this is common to all solutions because of the topographic characteristics of the existing waterfront.

C. Design Concept 2

This is similar to Design Concept 1, although based on the relocation of the airport to an alternative site. This would free a substantial area of approximately 185 acres for further community development. This would increase the capacity of the existing site to approximately 4,500 persons, more than adequate to accommodate the population growth anticipated over the next twenty years. In terms of centralized facilities, internal street access and major road lengths the pattern of development proposed is similar to that in Design Concept 1. This concept is illustrated on Plate 5. A summary of the advantages and disadvantages of this approach is presented below:

Pros

1. Relatively unlimited area could be made available for community development.
2. This would enable infilling and extension of the existing community, retaining the existing infrastructure.
3. Residential and industrial employment areas can be planned adjacent to one another, minimizing time-distance to work.
4. The expanded site has relatively better view characteristics than the riverside owing to greater elevation.

Cons

1. The airport would be relatively expensive to relocate and there may be disruption of service during new construction.
2. The cleared site would need substantial upgrading in terms of tree planting, etc. to make it attractive, which may be difficult and costly.
3. Both industrial and residential development would be isolated from the airport which provides a major communications service and employment source.
4. The community is isolated from the highway.
5. Extensive upgrading of the existing community is necessary so that it fits with new development.
6. Microclimatically the site may not be as desirable as a new townsite.

D. Design Concept 3

This alternative involves the development of a completely new site for residential and ancillary community development. The refinery and the airport would remain as two of the major employment areas. Existing buildings in the present townsite would be moved to the new community, and the old site would be available for expanded industrial use. Existing utilities and pile foundations should make the area readily saleable.

The site proposed is that recommended by J.D. Mollard and Associates (see Appendix F). Results of a preliminary soils investigation conducted by R.M. Hardy and Associates, (see Appendix H), indicate that the site is suitable for the development proposed. However, a considerably more detailed examination of the site would be required before the final location and design of the community could be determined. The concept shown on Plate 6 illustrates the general pattern of development which would probably be followed. The community would adjoin another major employment area, the highway service area, which could be serviced from the same utility system as the community itself. Good access would be provided by the highway access road, but would involve commuting to employment for many of the residents. The community is designed on a cellular pattern to enable gradual staged expansion. Again, major community facilities-commercial, school and recreational - are contralized for optimum access. Protection for residents between the highway access road and the community is maintained through retention of the major treed buffer strip.

The community illustrated occupies approximately 300 acres, 255 gross acres for residential development and 42 acres for non-residential development. This would have a capacity of approximately 3,600 persons. There is also provision for future expansion which could be made westwards towards Bosworth Creek and further expansion could take place across the highway access road if that were the

location chosen for that road. This in effect means unlimited capacity for development. Development may be staged according to need but the proposed initial stage of development could most conveniently take place within the major collector loop road.

The relevant factors for and against this alternative are presented below:

<u>Pros</u>

1. All employment areas are related and adjacent enabling good communication between them.
2. A new site for community development provides aesthetic advantages (surrounding bush, tree cover within site, extensive views of Mackenzie valley and mountains and isolation from refinery environment).
3. The community could be properly related to the highway which provides the principal access and a major employment source in highway services.
4. Adequate room could be made available for unlimited expansion.
5. The community could be isolated from any airport interference
6. A site could be chosen which has better ground and subsoil characteristics and hence lesser servicing problems.
7. It is possible to preplan the community as a whole, allowing proper relationships between the various parts of the community.
8. The existing townsite would be available for expanded industrial use.

<u>Cons</u>

1. Relocation costs would be involved in shifting existing housing.
2. Abandonment of existing infrastructure.
3. There would be "enforced" commuting to employment adding to personal costs and community costs in terms of road maintenance.
4. Some social disruption may be experienced and there may be an unwillingness to move on the part of some residents.

5. Timing and phasing of any move may be difficult which may be critical in terms of provision and operation of adequate facilities.
6. There is a possible danger of two communities developing, since it is unlikely that the Imperial Oil housing area would be moved, resulting in attendant social and organizational problems.

VIII. ENGINEERING ANALYSIS - SERVICES AND FACILITIES

A. Commentary and Alternatives

1. Water Supply

Bosworth Creek is the only reliable source of water in the Norman Wells areas, other than the Mackenzie River. The creek drains an area of approximately 42 square miles (26,700 Acres) on the southerly face of Discovery Ridge in the Norman Range of the Mackenzie Mountains, shown on Plate 3. This drainage area is much larger than that of many comparable streams tributary to the Mackenzie in this vicinity because of the fortuitous occurence of the Kee Scarp, which intercepts several smaller streams and diverts them into Bosworth Creek. Hodgeson Lake, behind Kee Scarp, provides a limited amount of seasonal storage and doubtless serves to partially regulate the flow of Bcsworth Creek.

Discharge measurements for Bosworth Creek are non-existant before 1973. In the summer of 1973 a stream gauging station was established by the Department of Energy, Mines and Resources, and the following results were obtained:

Date		Discharge - cfs
22 June 1973		12.3
13 July 1973		7.2
9 Aug. 1973		11.7
17 Aug. 1973		9.7
11 Sept.1973		13.6
	Mean:	10.9

This mean flow is equivalent to 5.92 million Imperial gallons per day, or to a yearly runoff of 3.6 inches from the 26,700 acre watershed. If the yearly mean flow

is assumed to be one-half of the summer mean, the yield would be 2.96 MIG/day, or 1.8 inches of annual run-off.

From such a short record, it is impossible to evaluate the capacity of the stream as a water source. In water supply engineering practice, a number of empirical formulae are used for preliminary assessment of stream-flow when data are lacking.

One of these, the Vermuele formula, attempts to relate annual runoff to mean annual rainfall and temperature as follows:

$$F = R - (11 + 0.29R)(0.035T - 0.65)$$

where: F = annual runoff, inches

R = mean annual rainfall, inches

T = mean annual temperature, degrees F.

Weather records are available only from the Norman Wells Airport (see Appendix D), which may or may not be representative of the watershed. From these records, mean annual rainfall (R) is 13.17 inches; and mean annual temperature (T) is 20.6 degrees F. From these data, the Vermuele formula gives a value of annual runoff (F) of 12.12 inches.

Also commonly used is the Justin formula, which in addition to rainfall and temperature, includes the slope and area of the watershed, as follows:

$$F = 0.934 \frac{R^2}{T} \left(\frac{D}{A}\right) 0.155$$

where: F, R, &T: as above

D = difference in elevation in watershed, high to low, feet (2,860)

A = area of watershed, square feet
(1.163×10^9)

Giving:

$$F = 5.36 \text{ inches}$$

The lower of these two empirical runoff values, 5.36 inches, is well in excess of that derived from the 1973 flow records. Therefore, it can safely be assumed that Bosworth Creek would provide a dependable supply, on a long term basis, of at least two million Imperial gallons per day.

Population projections contained elsewhere in this report indicate that Norman Wells can be expected to have a population of approximately 3,000 in the next 20 years. Allowing for a quite high per capita water consumption of 100 Imperial gallons per day, the water demand would be 300,000 IG/day (0.3 MIG/day). Allowing for a peak day of twice this amount, 0.6 MIG/day, demand would still be much less than the dependable supply of Bosworth Creek as derived above.

However, a problem of serious proportions exists in planning for the continued use of Bosworth Creek as a water source for the expanding community. It has been reported that in approximately one winter out of four the creek freezes to the bottom at a point about two miles upstream from its mouth, and that for a period of approximately three months there is no flow in this lower reach. In fact, this was the case during the winter of 1973-74. During this period, water was pumped from the Mackenzie River for domestic use. Fortunately the Mackenzie water is generally clear during winter and no problem was encountered from using this source. This would be true as long as Bosworth Creek begins flowing again before ice breakup on the Mackenzie, when the

river water would become too muddy.

The most preferable water source for the community would probably be Hodgeson Lake. A low dam could be constructed to raise the level of the lake slightly to provide ample storage, and quality should be excellent. Since the lake elevation is several hundred feet above the community, flow would be by gravity. However, the cost of constructing a long pipeline, and of protecting it against freezing, would make such a project too costly.

Another alternative would be the use of the Mackenzie River as the sole source of water. The quantity is certainly adequate at all seasons and regulatory storage would not be required. Quality would be acceptable in winter, but treatment for sediment removal would be required in summer, and particularly during and immediately after spring breakup. Also, power would be required to lift water from river level to the community. A permanent intake designed to resist or avoid ice damage would be costly.

The most feasible alternative for water supply for Norman Wells appears to be the continued use of Bosworth Creek. A small dam could be constructed a short distance upstream from the refinery complex, at the site previously investigated.(4). This dam could impound a reservoir large enough to provide sufficient storage to serve the needs of the community during a three month period when the creek might be frozen off. Alternatively, a smaller reservoir could be refilled by water pumped from a

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(4) References are to previous reports listed in Section II.

temporary intake in the Mackenzie River.

For the satellite community overflow area envisaged in Design Concept 1A, a supply pipeline could be constructed from the existing community, or a separate upstream intake on the creek could be provided.

For the new community of Design Concept 3, a dam and intake could be constructed on Bosworth Creek at a location upstream from the point where freezing might occur. A supply pipeline could then be provided to serve the refinery and any other facilities remaining at the existing site or they could continue to use the existing system. The possibility of combining the dam with the highway crossing should be investigated.

2. Water Treatment and Distribution

Available water quality analyses (see Appendix C), show that the Bosworth Creek water would usually require only minimal treatment; and treatment would be limited to the removal of iron, a comparatively simple process, plus chlorination and fluoridation. However, since the creek becomes turbid at higher stages, and since Mackenzie River water might at times be introduced, filters would be provided for sediment removal as required.

Correspondence with N.C.P.C.* has confirmed the Commission's interest in the use of available waste heat from their diesel - electric generating plants in various N.W.T. communities to supplement heat required for water system operations in these communities. They are of the opinion that a practical waste heat

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* Mr. B.G. Christie, Ass.t General Manager - Operations, N.C.P.C., March 1974.

recovery system is highly desirable to reduce fuel consumption and thereby improve overall efficiency of both operations and provide utility services at the least possible cost to the consumer.

The Commision is prepared to consider the installation of the necessary waste heat recovery equipment in the diesel plant, with the associated piping between the plant and the water system supplied and operated by the customer. Alternatively, the customer might assume responsibility for the cost of installing both the waste heat recovery system and the associated piping, in which case the Commission would apply a reduced rate for all heat supplied to the customer.

Because of the varying electrical demand on the power system, the Commission could not guarantee the amount of waste heat available for supply to the water system at any given time. Consequently, it would be essential that a back-up conventional heating system be installed to augment the waste heat supply.

The water treatment plant would be located as near as possible to the N.C.P.C. powerplant to simplify the installation of waste heat recovery piping between the two plants. As discussed above, a conventional heating system would also be installed to augment the waste heat supply as necessary. Because of the relatively large industrial load on the Norman Wells powerplant, it is probable that the waste heat would meet the need for heating of the water supply and utilidor system in all but the coldest weather.

For adequate fire protection for a community of 3,000 population, the Canadian Underwriters' Association

recommends that the water system be capable of supplying a continuous fire flow of 1450 Imperial gallons per minute (IGPM) for a period of 7 hours. This would require a minimum storage capacity of 609,000 gallons. Good practice would indicate the need for storage equal to one day's average use at the water treatment and pumping plant, or 300,000 gallons. The reservoir at the intake dam on Bosworth Creek would provide storage of several million gallons. The intake pumps would have a capacity of 1,200 IGPM, and at least 250 IGPM could be added from storage at the treatment plant to provide the recommended fire flow.

Water distribution under the permafrost conditions prevalent at Norman Wells will require heated above-ground utilidors similar to the existing system, regardless of the final form and location of the community. Considerable improvement is possible in the design of an integrated utilidor system, as discussed below.

3. Sewage Disposal Facilities

The "Public Sewerage System Regulations", established by the Commissioner of the Northwest Territories on 20 September 1972, require that all public sewerage systems meet certain reasonable minimum standards. Although certain elements of the existing Norman Wells system may be satisfactory, the overall system is not and an improved and integrated system is required.

In a report prepared for Environment Canada, dated 9 April 1973,(5), the proposed sewage disposal facilities for Norman Wells were described as follows:

"Treatment is achieved in an anaerobic-aerobic lagoon system. Two primary cells would be built adjacent to a small lake near the west end of the airport. These

cells would be operated in series or parallel, and would provide excellent 'primary' treatment. The 'primary' effluent would then be discharged to the small adjacent lake, where further treatment would take place through aerobic action during the summer months, approximately June to October inclusive".

"To provide 'secondary' (aerobic) treatment for sewage collected during the winter, the lake which accepts flow from the two artificial cells can be dammed to provide winter storage of all effluent. Discharge from this lake would be controlled to spring and fall only, with the spring discharge occuring after ice breakup and establishment of aerobic conditions in the lake. Ponding would have to be sufficient to retain eight months sewage flow, as aerobic action in the secondary pond (lake) would cease during the winter months when snow and ice cover arrested photosynthesis and algae growth, necessary to the aerobic process."

"It is proposed that discharge be to a chain of small lakes and creeks which flow eastward. This flow is intercepted by a stream running from the hills to the north into the Mackenzie River, about four miles to the east of Norman Wells. The type of treatment proposed provides excellent reduction of B.O.D. and solids, and is more than equivalent to primary mechanical treatment. Rentetion for secondary treatment promotes die-off of bacteria and, probably, of viruses."

"Odour in the immediate area of the lagoons is possible for a period of about one week in the spring, when the ice cover on the secondary lagoon is broken exposing anaerobic lagoon contents to the atmosphere. Immediately upon establishment of aerobic action in the surface layer of the lagooned liquid, odour will be

diminished to a minimum. Climatological data for Norman Wells shows wind from the north-northwest quadrant (towards the near edge of the settlement from the lagoon site) an average of twelve per cent of the time in the month of June, when this conversion would occur. The distance from the edge of proposed development to the lagoon site is approximately 5,000 feet, and odours at this distance, even under unfavourable wind conditions, will not be significant."

"The lagoon system would be fed by a sewage forcemain carrying sewage from a main pumping station located near the site of the septic tank installed south of the new commercial centre. This pumping station, in turn, would receive sewage pumped and gravity-drained from the balance of the community through the utilidor system. The existing new 7,000 gallon septic tank and outlet should be preserved and maintained to provide an emergency overflow, (with septic tank treatment) in the event of a failure in the main pump station or forcemain."

The proposed disposal facilities discussed above are adaptable to any of the community design concepts presented in this report. For Design Concept 3, the new community, or for Design Concept 1A, the overflow area, the two primary cells would be sited on the northerly side of the small lake. Flow from the new area would be by gravity, while the force main from the existing community would be extended across the low, wet area on piling to the lagoons. For Design Concept 2 the cells would be sited southerly of the lake.

4. Sewage Collection System

Water-carried community sewage collection systems in permafrost areas are very costly, partly because of the problems of combating low temperatures, frost action and permafrost. Sewers, like water lines can be kept operative only if they are protected from freezing, and from differential movement owing to frost action in the seasonally thawed layer or thawing of the permafrost. Enclosing the sewer in a heated utilidor is the best way of ensuring trouble free operation, though these installations are expensive. With above ground utilidors, adequate supports to maintain proper alignment of pipes for gravity sewers are essential. In fine-grained soils with high moisture contents subject to thaw settlement, such as those at Norman Wells, piling anchored in the permafrost may be required.

An alternative to the use of gravity sewers has recently been under development in the United States. This is a low pressure sewer concept which utilizes individual household storage grinding pump units. These units were developed as part of an overall system to meet specific criteria originally established in 1966 by the ASCE Combined Sewer Separation Project Steering Committee. The grinder pump unit was developed, tested, improved, field evaluated and converted into a reliable production design over a five-year period. Its reliability and suitability for the intended purpose have been established in extensive demonstration projects completed last year by the New York State Department of Environmental Conservation and jointly

funded by the Environmental Protection Agency.*

The low pressure sewer system appear to be ideal for use in a northern environment. Sewer mains can be plastic pipe in diameters of 4 inches and smaller, thus reducing the size and heating requirements of utilidors. Freedom from the need to maintain continuous downward grades for gravity flow of sewage has many advantages. Houses do not have to be elevated above utilidor grades; utilidors can follow the ground surface and do not require elevation on piling to cross low areas; utilidors can be depressed at road crossings; subdivisions and building locations can be layed out to best suit topography and traffic circulation requirements with minimum consideration for utilidor grades; and utilidors can be placed on gravel fills, rather than expensive piling, since differential movement will not disrupt pressure flow.

The mechanical reliability of the grinder pump unit and the nature of the low pressure sewer system have been established and the necessary engineering design parameters documented. Because of this, the system can be considered available engineering technology. Therefore, only the economics of the pressure system versus the gravity system for a particular project need be considered. Such an economic analysis is beyond the scope of the

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* "Pressure Sewer Demonstration", by Carcich, Hetling and Farrell; Journal of the Environmental Engineering Division, Proceedings of the American Society of Civil Engineers, Vol.100, No.EE1, February, 1974.

present study, but should be made during the preliminary design stage prior to any future expansion of Norman Wells. This analysis would also consider other alternatives to gravity sewers, such as pneumatic and vacuum systems.

5. Utilidor System

The existing utilidor system at Norman Wells was constructed over an extended period of time and various portions of it have been reconstructed or rehabilitated, most recently in 1973. As long as an ample source of heat was available in the form of steam from the refinery, insulation was not of primary importance. Now, however, steam will soon be unavailable and the steam and condensate lines will either be removed from the utilidors or converted to other uses. In the future, heat for the utilidor system must be provided from other sources at increased cost and improved insulation of the utilidors will be essential.

One factor in the high cost of past utilidor construction has been the relatively high proportion of field labour required. Recent developments in the design and construction of insulated and heated utility systems, both in Alaska and in northern Canada, hold promise for reduced cost and improved performance. The U.S. Indian Health Service is engaged in a program for the improvement of water and sewer services in many native communities in Alaska, for which they have developed an insulated pipe consisting of a polyvinylchloride plastic carrier pipe surrounded by a corrugated aluminum culvert with the annular space filled with

foamed-in-place urethane insulation which is used for essentially all water distribution and sewage collection lines.* The sizes of the inner carrier pipe and outer protective pipe can be varied to provide the needed flow capacity and correct amount of insulation. More than one carrier pipe can be placed within a single outer pipe, and either electric heat tapes or separate pipes for circulating hot water heating can be provided. This system has been adapted for use in the many construction camps now being constructed for the petroleum industry throughout the North.

A decided advantage of this insulated pipe system - called "utiliduct", rather than utilidor by its developers - is that the pipe sections, usually in twenty foot lengths, are fabricated to order in the manufacturer's plant and delivered to the jobsite ready to install. Field labour is thus greatly reduced and problems with material shortages are practically eliminated. Special fittings such as elbows and branches, cleanouts and manholes can be prefabricated to suit the particular installation. This "utiliduct" system would be particularly adaptable to the low pressure sewer system discussed above, though it would be equally suitable for use with gravity sewers.

6. <u>Solid Waste</u>

The existing dump site is located adjacent to and down-

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* "Design and Construction of Practical Sanitation Facilities for Small Alaskan Communities", by William L. Ryan, U.S. Indian Health Service; in <u>PERMAFROST:</u> The North American Contribution to the Second International Conference, National Academy of Sciences, Washington, D.C., 1973.

hill from the quarry, about 3.5 miles from Norman Wells, as shown on Plate 3. In its present condition the dump is a potential fire hazard because of the large amount of combustible waste deposited therein. It is in a forested area and no clearing has been done. A fire on the dump, whether started accidentally or purposefully, could easily spread and cause a serious forest fire. Because the waste cannot be burned during much of the year, windblown debris is spread over a wide area.

A report prepared for Environment Canada, dated March 1973, (7), contains an excellent discussion of the problems of solid waste management in the North. The report recommends that solid waste either be hauled to a sanitary landfill site for disposal where soil and permafrost conditions are suitable; or hauled to a central storage area for processing either by incineration or baling. If baling is performed, the bales may be temporarily stored on site until disposal can be conveniently done at a landfill site that meets land use regulations. If incineration is the process, the residue should be hauled to an approved landfill site.

The referenced report also recommends a pilot program and further studies which, if implemented, could result in developments applicable to the Norman Wells situation. At present, the equipment required for either baling or incineration is expensive to install and to operate, and in either case a landfill site is required for ultimate disposal.

The operation of a sanitary landfill under permafrost conditions presents many problems. These are discussed

in another report prepared for Environment Canada,(6), which contains the following:

"Sanitary landfill is a common form of sanitary waste disposal in the southern urban centres of Canada. A properly operated landfill avoids the major disadvantages of open dumps. The protectice cover of earth allows sanitary decomposition of the waste without attracting animals, prevents the breeding of disease carrying insects, reduces the occurrence of strewn litter, and eliminates obnoxious burning."

"However, there are disadvantages to sanitary landfills, particularily in the Arctic environment.

(a) Landfill operations require expensive earth-moving equipment and trained personnel to operate it. Operation of the equipment in extremely cold weather can present difficulties.

(b) Decomposition in landfill sites is extremely slow in the Arctic, although it is not particularily fast in other parts of Canada where successful landfill sites are operating.

(c) Landfill in Permafrost areas presents unique problems. There is a danger that pathogenic material frozen in the Permafrost will survive indefinitely to be released as viable organisms if the site is disturbed in the future. In addition, excavation of a trench will cause slumping in the spring and summer as the disturbed Permafrost melts. This may necessitate expensive shoring of the trench or create unmanageable mud holes.

(d) Although land is plentiful and inexpensive in the North, the amount of available cover material is

limited in many locations, and in most Permafrost regions, the depth of the protective active layer is very shallow.

(e) Water pollution is a potential problem in landfill areas, particularily in the North where surface drainage is poor."

"For large municipalities, a sanitary landfill is quite economical and easy to operate compared with some other methods. As the size of community decreases, however, the cost per capita of sanitary landfill becomes increasingly greater because so much of the cost is fixed. Thus, it is likely that other methods will be more suitable for many communities in the North."

"Nevertheless, sanitary landfill does offer a possible solution to solid waste disposal, and should be thoroughly investigated to determine where it can be used satisfactorily in the North."

"A study should be undertaken to identify potential landfill sites for each community where there is sufficient cover material and where there is adequate depth of active layer in Permafrost regions. Consideration should be given to using old borrow pits or abandoned mines as disposal sites. Other suitable locations would be small embankments where the refuse can be bulldozed over and covered regularily."

A study such as that recommended above should be undertaken for Norman Wells. At the present dump site cover material is available in the waste stripped from the quarry. Other sites may be created by the excavation of borrow pits for the proposed Mackenzie Highway. Operation of a sanitary landfill should be combined in a single contract for collection and hauling of solid

waste from the entire community.

7. Electricity

The existing powerplant has ample reserve capacity for present conditions. Planning by N.C.P.C. has taken cognizance of the potential growth of the community and the plant will be expanded as necessary to accommodate future demands. If development takes place in the proposed new site, the area would be served by a transmission line from the existing powerplant.

8. Fire Protection

Norman Wells is presently without fire protection in any organized sense. A local volunteer fire unit, with its own equipment and building, should be provided. This unit would provide fire protection for the community and by interchange agreement would serve as a coordinating agency when Imperial Oil or M.O.T. equipment was called upon for assistance.

9. Surface Drainage

Collection and drainage of surface flows, both from precipitation and from melting permafrost, is an item of major importance for the future development of Norman Wells. In the existing townsite, possible drainage improvements previously recommended by others have been only partially implemented. Deepening of ditches and lowering of culverts in several locations would be of benefit to the existing community, regardless of any future developments. In the design of any such developments, consideration must be given to facilities for surface drainage and to the scheduling of their construction.

Proposed Improvements

1. General

One of the prime objectives of this report is the presentation of all factors, including estimated costs, which enter into the decision making process involved in the selection of the most feasible and desirable plan for the future development of the community of Norman Wells. Three alternative design concepts are presented, each of which would accommodate the needed development. The improvements required for implementation of each of these design concepts would be similar in nature, but would differ somewhat in their scope and cost. Presented herein are the improvements recommended for each concept, together with estimates of the approximate costs of these improvements.

2. Water Supply

a. Existing Townsite and Overflow Area

The primary water supply for the existing townsite in Design Concepts 1 and 2 and for the overflow area in Design Concept 1A would come from Bosworth Creek. A graded rockfill dam would be constructed a short distance upstream from the refinery complex, at the site previously investigated,(4), as shown on Plates 3 and 7. Previous soils investigations indicate that onsite materials would be unsuitable for use in an earthfill dam. The clayey materials encountered at the site might be suitable for the core of a rockfill structure, except for their high moisture content. Since there would not be sufficient time or enough dry weather during the short summer construction season at Norman Wells to dry this material sufficiently for compaction, it is not considered useable. All the material would therefore have to be imported from the quarry.

It is proposed that the dam would be a homogenous rockfill dam in which the rock is so placed that the largest fragments are on the upstream and downstream faces and the average size of the fragments decreases until only very fine material is used at the centre. The correct gradation of rock could be obtained by crushing and screening at the quarry. It is extremely unlikely that blasting could achieve the desired result due to the structure of the rock in-situ. The advantages of an entirely rock filled dam are that the

amount of material used would be comparatively small, due to the steep side slopes, and that any settlement due to degredation of the permafrost at the abutments could be readily accommodated. Further advantages are that construction of a rock fill dam could proceed during the winter and, indeed, it may well be more economical to construct such a dam during cold weather. A seepage cut-off would be required in the gravel zone below the dam. Details of the proposed dam and appurtenances are shown on Plate 7.

The service spillway would consist of a 48-inch corrugated metal pipe under the easterly end of the dam. The entrance to the service spillway would be at elevation 195, approximately 25 feet above the level of the streambed, providing a minumum of 30 million Imperial gallons of active under-ice storage. This storage would be equivalent to a 3 month supply for a community of 3,000 population, and would be ample to meet the demand during a winter period when the creek might be frozen off upstream.

In addition to the service spillway, which would pass all normal streamflows, there would be an auxiliary spillway over the center of the dam. This would be a 50-foot section with an elevation of 197, three feet lower than the crest of the dam at elevation 200. A grid work of welded reinforcing rods would be placed over the surface of the rockfill so that flows over the embankment would not displace the rock. This grid would be

welded to rods which are anchored into the rock-fill.

The water intake and service spillway entrance would be combined in a single structure near the easterly abutment of the dam. This structure would consist of a 10-foot CMP placed vertically on a concrete foundation. A 60 inch CMP riser inside this structure would connect with the service spillway pipe. Several screened gate openings would admit water to the annular space between the inner and outer pipes. The two 600 IGPM turbine intake pumps would draw water from this annular space. A small intake pumphouse would be mounted on the top of the 10 foot CMP, and would be connected to the crest of the dam by a footbridge. All water not used by the pumps would flow over the top of the inner pipe riser and be discharged through the service spillway. A gate at the bottom of this riser would allow the reservoir to be drained for cleaning. The combined intake and spillway arrangement would allow formation of a solid ice cover in the reservoir in winter. All outflow would be at a single point, thus assuring that the intake will remain operative at all times. Intake gates would be at two levels so that the water stratum of best quality could be used.

The intake pumps would discharge through a 8 inch insulated supply main approximately 5,700 feet long leading to the water treatment and pumping plant. This main would be heated by a circulating hot water system, which would also supply heat to

the intake pumphouse.

Imperial Oil has indicated that they would like to be relieved of the responsibility for supplying water to the community of Norman Wells. They also indicate that if a public water supply system is installed they would desire to purchase water for domestic use from this system. They would, however, continue to maintain their existing Mackenzie River supply for refinery process water. Thus, this source would still be available as an emergency supply in case of breakdown of the Bosworth Creek system.

The Bosworth Creek intake dam, complete with spillways, intake structure and pumphouse, and insulated supply main is estimated to cost approximately $560,000. This cost would be applicable to both Design Concepts L-1A and 2.

b. New Community

For the new community alternative of Design Concept 3 the primary water supply would also come from Bosworth Creek. However, the intake dam would be located at a point upstream near the new community site. No detailed site investigation have been conducted at this location, but visual inspection indicates the probability of exposed bedrock and a more favourable foundation for a dam. This site would probably be above the point where the creek periodically freezes off, and long term storage might not be required. Future investigations might prove the suitability of onsite materials for dam construction, but this cannot be relied upon at this time. The supply main would be somewhat

shorter, approximately one mile, but necessary clearing and road construction would increase the cost.

Recognizing the lack of adequate data upon which to base a cost estimate, and considering the estimated cost at the downstream site, it is estimated that the intake dam and appurtenances would cost approximately the same, nearly $560,000.

A combination of the dam and the highway crossing of Bosworth Creek should be considered. This should result in some savings.

3. Water Treatment and Pumping Plant

a. Design Concept 1 and Overflow Area 1A

The water treatment plant would provide for the removal of iron, chlorination, fluoridation and filtration. The plant would have an ultimate capacity of 600,000 Imperial gallons per day, double the average consumption, but equipment could be installed in increments as the demand grows. Storage capacity of 300,000 IG would be provided at the plant site, in two 150,000 IG tanks.

The plant would be located adjacent to the N.C.P.C. powerplant in order to utilize waste heat from the diesel generators. Oil fired boilers would also be installed to augment the waste heat supply. A standby diesel generator would be provided to power the heating and circulating system in emergencies to prevent freeze-up of the water system.

Distribution pumps with a capacity of 600 IGPM would meet the ultimate demand on the system, and a

1,450 IGPM diesel-driven fire pump would be adequate for fire protection. Circulating pumps for the distribution system would be installed in the plant. A modern control and alarm system would be included to indicate temperatures and pressures at remote points in the water system and to give warning of any incipient freezing problems, to facilitate one-man operation.

Normal water plant practice, with below ground concrete pump wells and buried concrete storage reservoirs, would not be feasible in the permafrost conditions prevalent at Norman Wells. The treatment plant building would be a metal frame structure resting on piling, with separate pile foundations under heavy units such as tanks and boilers. Storage would be in insulated steel tanks supported on gravel pads. Metal pipes through the pads would provide air circulation in winter to help preserve the permafrost under the tanks.

The water treatment and pumping plant, complete with storage tanks and all equipment, is estimated to cost approximately $600,000. Of this cost, it is estimated that approximately $150,000 could be deferred by delaying sonstruction of one of the storage tanks and installation of some of the equipment until late in the 20 year planning period. Initial cost would then be an estimated $450,000.

b. <u>Design Concept 2</u>

The water treatment and pumping plant described above for Design Concept 1-1A would also be used for Design Concept 2. The estimated costs would also be the same; approximately $450,000 for the initial installation; $150,000 for deferred construction; and a total of $600,000.

c. <u>Design Concept 3</u>

The design of the water treatment and pumping plant for Design Concept 3 would be similar to that described above for Design Concept 1-1A. The plant would be located somewhere near the upper fringe of the new community or near the intake dam. Because of the slope of the site a gravity water system might be possible, thus reducing pumping costs. Because the plant would be separated from the N.C.P.C. powerplant no use could be made of waste heat from that source. This would reduce the initial cost slightly by elimination of the heat recovery equipment and associated piping, but this would be compensated for by an increase in size of the conventional heating system. Operating cost of the heating system would be increased but this factor would be difficult to analyze at this time.

For planning purposes, no change in estimated cost will be made and the costs estimated above will also be used for this concept; approximately $450,000 for the initial installation; $150,000 for deferred construction; and a total of $600,000.

Water Distribution Mains

a. General

Utilities systems in Norman Wells must, of necessity, be place in utilidors. It is difficult, theref ore, to separate the costs of water distribution and sewage collection. Accordingly, discussion and costs of the utilidor system will be treated in a subsequent paragraph. The present discussion will be limited to those water mains which would not be placed in common utilidors with other services.

b. Existing Townsite

From the proposed water treatment and pumping plant an 8 inch insulated distribution main would extend approximately 1,500 feet easterly, as shown on Plate 7, to a point where it would join the main ulitidor system and feed the branch mains contained therein. This main, estimated to cost approximately $75,000, would be common to both Design Concepts 1 and 2.

The utilidor system in the area of existing housing development is gradually being upgraded, and would also be fed by the new distribution main. The existing main from the present water intake pumphouse would be fed directly from the treatment plant to serve the Imperial Oil area.

For design Concept 3, it would probably be too costly to provide water service from the treatment plant at the new community site to the Imperial Oil housing area and any other development which might remain at the existing townsite. Therefore, it is considered that for this alternative the

present water supply system would remain in service to supply any remaining demand in the existing townsite.

c. Overflow Area

The overflow area in Design Concept 1A would receive its water supply through a main from the proposed water treatment and pumping plant in the existing townsite. This 6 inch insulated main would have a length of approximately 10,000 feet and would cost an estimated $400,000. This cost is based on the main being supported on piles for one-half its length across the low, wet area west of the airfield, and on gravel fill for the remaining 5,000 feet. A small booster pump station with a 50,000 IG storage tank would be provided to serve the overflow area, with a cost estimated to be approximately $100,000.

Future investigations might show that a separate water intake and treatment plant could be provided for the overflow area at lesser costs than those presented above, but these estimates will be used for planning purposes.

d. New Community

For the new community of Design Concept 3, the water treatment and pumping plant would be located near the fringe of the community and no separate distribution mains would be required.

. Sewage Disposal Facilities

The proposed sewage disposal facilities would be as described in paragraph A.3., herein. They would consist of an anaerobic-aerobic lagoon system. Two primary cells, each 90 feet square at the top and fifteen feet

deep, would be built adjacent to a small lake near the west end of the airfield. For Design Concepts 1-1A and 3 the cells would be sited on the northerly side of the small lake; for Design Concept 2 they would be sited southerly of the lake. Effluent from the primary cells would discharge into the adjacent lake where further treatment would take place through aerobic action during the summer months. The level of the lake would be raised by a small weir to provide winter storage of all effluent. An increase in level of one foot would accommodate eight months storage for a population of 3,000. Discharge from this lake would be controlled to spring and fall only, with the spring discharge occurring after ice breakup and establishment of aerobic conditions in the lake.

The cost of the two primary cells and the lake level control weir is estimated to be approximately $200,000, which would be the same for either location of the cells.

. Sewer Trunk and Force Mains and Pumping Stations

a. Existing Townsite - Design Concept 1

The lagoon system would be fed by a sewage forcemain carrying sewage from a main pumping station located near the site of the main septic tank in the existing development area. This pumping station, in turn would receive sewage pumped and gravity-drained from the balance of the community through the utilidor system. The main sewage pumping station is estimated to cost approximately $145,000.

The sewage forecemain would have a length of approximately 5,000 feet from the main pumping station to the lagoon site. Of this distance, approximately 1,500 feet would be installed in a

combined utilidor and its cost is not estimated separately. The remaining length of approximately 3,500 feet would be a separate insulated pipe, with electric heat tracing provided for occasional periods when heat was required, estimated to cost approximately $175,000.

A smaller sewage pumping station, estimated to cost approximately $95,000, would be required to serve the area easterly of the town centre. This station would also serve the airport terminal area and the adjacent commercial development.

b. <u>Existing Townsite - Design Concept 2</u>

This concept would require a main sewage pumping station similar to that for Design Concept 1, also estimated to cost approximately $145,000. The sewage forecemain would have a length of approximately 4,000 feet, of which about 1,500 feet would be in a utilidor. The remaining 2,500 feet of insulated pipe is estimated to cost approximately $125,000. Two smaller pumping stations would be required, one to serve the northwesterly portion of the community and one the easterly half of it. These stations are estimated to cost approximately $95,000 and $110,000, respectively.

c. <u>Existing Townsite - Design Concept 3</u>

All existing residential development, with the possible exception of the Imperial Oil housing, would be moved to the new community site. It is, therefore, considered that any sewer mains and pumping stations required to serve the Imperial Oil complex would be installed by Imperial Oil.

Likewise, if such facilities are required to serve the airport terminal area or the commercial area near the airport, it is assumed that these also would be installed at no expense to the N.W.T. Government. Any future light industrial expansion in the existing townsite would produce only minor amounts of sewage, which could be accommodated by pump-out tanks or individual sewage facilities.

d. <u>Overflow Area and New Community</u>

The overflow area of Design Concept 1A and the new community of Design Concept 3 would be located at a higher elevation than the sewage lagoons, and sewage would flow to the lagoons by gravity. This would require a gravity main, insulated and electrically heat traced, approximately 8,000 feet in length. Size of themain would be the same in either case; only the length and discharge capacity would vary with the tributary population. The gravity main, would cost an estimated $350,000.

. <u>Sewage Collection System</u>

The problems involved with sewage collection systems in a permafrost environment and the alternatives available for their solution were discussed in paragraph A.4. herein.Sewers must be enclosed in heated above ground utilidors for effective protection from freezing. For gravity sewers it is essential that straight gravity grades be maintained at all times and rigid support by pilings anchored in the permafrost is necessary. For a pressure sewer system, mains would be smaller in size and they could be enclosed in a

flexible "utiliduct" placed on a gravel fill. Differential movements would not disrupt pressure flow, and only periodic adjustments would be necessary to correct thermal movement of the supporting subgrade. For the pressure sewer system, individual grinder pump units would be required in each residence or group of multi-family units; but buildings would not have to be elevated to assure flow into a gravity system.

It is believed that the savings in construction and heating costs for utilidors, plus the reduced cost of building foundations, would more than compensate for the cost of installation and operation of the grinder pump units The greater flexibility possible in subdivision layout and building locations is difficult to evaluate, but would be a decided advantage for the pressure sewer system. A detailed comparison of gravity and pressure sewer systems is beyond the scope of this report; however, it is strongly recommended that such a comparison, involving engineering and economic analysis of all aspects, be performed before any commitment to either system is made, that is, before any further construction of utilidors at Norman Wells other than rehabilitation of the existing utilidor system. This study would also consider other alternatives to gravity sewers, such as pneumatic and vacuum systems.

It would be difficult to estimate the overall costs of sewage collection, by either system, without having available the detailed subdivision design for each of the community design concepts under consideration.

Since such detailed design would be premature until the final form and location of the future community have been determined, estimated costs for the combined utilidor system were determined as discussed in the following paragraph.

<u>Utilidor System</u>

As explained above, the overall cost of the utilidor system cannot be estimated prior to detailed subdivision design for each alternative community design concept. Therefore, trial designs in preliminary form have been prepared for a hypothetical subdivision which would be typical of the plans under consideration. As shown in Appendix E, trial designs and cost estimates were prepared for three alternatives, as follows:

(1) "Conventional" utilidor system, as used in the most recent utilidor reconstruction at Norman Wells.

(2) "Utiliduct" system, with gravity sewers.

(3) "Utiliduct" system, with pressure sewers.

To simplify this analysis, no cost has been included for the utilidor heat supply, since the source of heat would be in the water treatment and pumping plant and its cost has been included in the total estimated cost of that facility. Likewise, no evaluation has been made of the variable cost of building foundations, or of the cost of operation and maintenance. These factors would be included in the more detailed study recommended above.

The trial cost estimates derived in Appendix E were converted to typical costs per unit of housing for each of the three alternative utilidor systems as follows:

(1) $8,600
(2) $6,800
(3) $7,700

For planning purposes, the highest of these estimated costs, $8,600 per unit of housing for alternative 1, will be used as a multiplier for determining the estimated costs of incremental expansion of the community for each of the Design Concepts.

9. Solid Waste

As previously stated, the present dump is unsatisfactory as a disposal site for the solid waste from the community. Although better sites may be created by excavation of borrow pits during construction of the proposed Mackenzie Highway, the present site is the most favorable now available for creation of a sanitary landfill. Improvements necessary to accomplish this objective would include clearing of the surrounding area; shaping, compaction and covering of the previously deposited material; and stockpiling of at least one year's supply of covering fill. This preparatory work is estimated to cost approximately $10,000. A contract should then be entered into annually for collection and hauling of solid waste and operation of the sanitary landfill. Alternatively, this work could be done by local government personnel.

The equipment required for alternative methods of solid waste disposal, either baling or incineration, is expensive to install and to operate. However, studies underway by Environment Canada could result in development of an improved system in the future which would replace the sanitary landfill.

10. Fire Protection

A local volunteer fire unit should be formed. Equipment for this unit, including a pumper truck with a 1,000 gallon water tank, is estimated to cost approximately $25,000. A building to house the fire equipment could

be incorporated with a municipal building which would accommodate all public offices in the community. The fire station portion of this structure, with an area of 1,500 square feet, is estimated to cost approximately $60,000.

11. Roads

a. Highway Access Roads

It is understood that as part of the construction program for the proposed Mackenzie Highway, the Federal government will construct access roads from the highway to each of the communities along its route. Because of the unusual situation at Norman Wells, with the residential community located between the Imperial Oil refinery complex on the west and the airport road industrial area on the east, a single highway access road at either end of the community would result in a passage of heavy industrial traffic through the residential area. Therefore, it is considered that provision of two highway access roads, one at each end of the community as shown on Plate 3, would be justified and that these roads would be constructed at Federal expense.

b. Local Roads and Streets

The location of the local roads and streets required to serve the various portions of the community would be generally as shown on Plates 4 through 6. Horizontal gradients would be determined by the topography of the particular site, except at utilidor overpasses, but would in all cases be less than five percent. Roadway width would be 30 feet, with a 4 percent crown and 3 to 1 side slopes. Ditches at least one foot deep would be provided to carry drainage and corrugated metal culverts would be installed as necessary.

In the low-lying areas in and adjacent to the present townsite roadway fills would average five feet in height above the present land surface. In the new community area it is assumed that three feet of fill would be adequate for local traffic, with four feet on the main loop road. Better foundation conditions in the area covered by the existing airport to be incorporated in Design Concept 2 would allow reduced roadway fills, estimated to average two feet in height. All fill material would be obtained from the existing limestone quarry.

On these bases, the approximate costs per foot of local roads and streets are estimated to be as follows:

	Height of Fill	Cost per foot
(1) Design Concept 1 and 1A:		
(a) Existing townsite:	5'	$45
(b) Overflow area, main loop:	4'	$35
(c) Overflow area, local:	3'	$25
(2) Design Concept 2:		
(a) Existing townsite:	5'	$45
(b) Airport area:	2'	$15
(3) Design Concept 3:		
(a) Main loop:	4'	$35
(b) Local:	3'	$25

12. <u>Surface Drainage</u>

An adequate drainage system for the existing community should be developed as an early priority item. This would require improvements to several existing culverts and deepening of drainage ditches. Provision would be made where necessary to allow for flow of drainage from adjacent areas as they may be developed. This work, estimated to cost approximately $15,000, should be performed regardless of which design concept is selected.

Provisions for surface drainage would be incorporated in the design of each phase of development for whichever design concept is selected, and cost would be included in site development costs.

13. Landfill and Building Foundations

a. Existing Townsite

The subject of landfill for the existing Norman Wells townsite was extensively covered in a report prepared by the Department of Public Works of Canada,(11). This report considered two possible alternatives for placement of landfill in the first phase expansion area northerly of the existing townsite: Utilization of hydraulic fill from dredging which may be done in the interest of navigation improvements in the Mackenzie River, and of conventional borrow material from the existing limestone quarry. The report recommended that no further consideration be given to stabilizing the site by the utilization of hydraulic fill; and that, if the site is to be developed, conventional methods and sources of fill and embankment materials be utilized.

Based on the site and plan of development studied, the report concluded that the estimated cost of landfill by conventional methods would average $9,825 per lot. For planning purposes, and considering the variation in conditions of the existing townsite, it is estimated that landfill costs would be approximately $10,000 per lot to provide an average depth of fill of 2½ to 3 feet, which would develop an adequate structural strength to support light vehicles.

Foundations for buildings which can withstand relatively

little movement, in the areas to be filled, would consist of steel pipe piles driven to bedrock at a depth of approximately 25 feet. As an alternative for buildings where floor loads are heavy and perhaps concentrated, as in garages and repair shops, and where elevated floors are not practical, insulated concrete slabs on ventilated gravel pads could be used. Buildings capable of withstanding some movement could be based on filled pads of stable material of depths not less than five feet.

b. Airport Area

In the area covered by the existing airport to be incorporated in Design Concept 2, no additional stabilizing landfill would be required. Additional soils investigations would have to be made prior to design of building foundations, but for purpose of this report it is assumed that single-family residential buildings could be constructed on post and footing or strip footing foundations in this area.

c. Overflow Area and New Community

The soils investigation conducted at this site (see Appendix H) indicates that the typical soil profile consists of organic soil, sometimes peat, overlying till. Layers of silt, sand and gravel are quite commonly found enclosed within the clay till.

In order to ensure that a supply of water required for frost heaving is not made available, the sites of all buildings should be graded so as to shed excess water from rain or snow melt as quickly as possible. Fill would be required only beneath structures or in parking or material storage areas, in addition to roads and streets. Costs for site grading and fill for driveway

and pad beneath the building are estimated to be approximately $1,700 per lot.

For small buildings or mobile homes a suitable foundation would be a gravel pad of at least two feet in thickness, with the building placed on top resting on cribs or blocks of wood. If the necessity for relevelling such a building at periodic intervals is accepted such a foundation would be quite satisfactory. However, this type of foundation is recommended only for small buildings of timber frame and no more than one storey in height.

For larger buildings, or where periodic levelling is not acceptable, a pile foundation would be the best solution. The minimum depth of embedment of piles should be 30 feet. All piles should be driven, not placed in predrilled holes, so that only steel piles are likely to be economical. Salvaged drill stem with a minimum outside diameter of 4 inches or thick walled steel pipe may be used for piling and, for exceptionally heavy loads, it may be economical to use steel H-piles. Driven steel piles would be designed on the basis of an allowable skin friction of 300 psf.

. <u>Airport</u>

a. <u>Improvements</u>

It is understood that M.O.T. is currently planning to construct a new and enlarged terminal building at Norman Wells. A program for improving navigational aids is continuing. Some consideration has been given to an extension of the paved runway from 6,000 feet to 8,000 feet in length, and this may be done when traffic growth justifies the cost. Any improvements which may bemade to the Norman Wells airport will be Federal

responsibilities and will not directly affect the funding program of the N.W.T. government.

b. Relocation

Design Concept 2 would require the relocation of the airport to an entirely new site. Preliminary contacts with M.O.T. representatives in Edmonton produced a negative response and no information could be obtained regarding possible alternative locations for the airport or the probable cost of relocation. Therefore, for the purposes of this report the following assumptions are made.

(1) There exists an alternative site for an airport of the type and size required at Norman Wells.

(2) Such a site would be readily accessible from the community of Norman Wells, and housing and other service facilities would remain at the community.

(3) Cost of construction of the new airport, and of relocating all facilities which would require relocation, would be in the order of $6,000,000.

It must be recognized that to resolve the validity of these assumptions, that is, to locate a suitable site and to perform sufficient exploration and design studies to determine costs, would be beyond the scope of the current studies.

15. Soils Information

The westerly portion of the existing townsite, the area north of the present residential area, has been explored in some detail. Test hole information for this area is contained in references (5) and (11) and in Appendix G.

The more easterly portion of the existing townsite has not been investigated, but surface inspection indicates that soil conditions are similar in this area. Results of a prelimiary soils investigation of the proposed new community area are included in Appendix H.

16. <u>Granular Materials</u>

The Granular Materials Inventory (9) was referred to in assessing alternative sources of borrow material for landfill, roadway and dam embankment. The existing limestone quarry, shown as Site NW4 in the Inventory, appears to be the only presently available source of such material. It has been reported that explorations conducted for the proposed Mackenzie Highway have located one or more potential borrow sources closer to Norman Wells, and when developed these may provide more economical sources of material.

17. <u>Schools</u>

Previous discussions in this report have indicated the range of growth in school population predicted. On the basis of the low population projection, there will be a definite need for 6 classrooms by 1978. Because the existing 3 room school is of temporary construction, an entirely new school should be planned for. This would include 4,800 square feet for 6 classrooms; 2,400 square feet for offices, hallways, etc.; and 2,400 square feet for a gymnasium. The latter is a much-needed facility which would also be useable for community recreational activities. The 9,600 square feet structure, at an estimated cost of $45 per square foot, would cost approximately $432,000.

Expansion of the elementary school to 10 classrooms would be required by 1983 under the high population projection,

and by 1988 under the low projection. Further expansion of elementary school facilities might take the form of addition of more classrooms to the first school or of construction of a second school. High school population will reach 50 in 1983-88 and construction of a high school should be considered at that time.

18. Municipal Building

It is anticipated that Norman Wells will achieve Hamlet status within one or two years. The additional responsibilities of local government will require adequate office space; also, space will be needed for public works maintenance and storage. This would require a building with a minimum area of 3,500 square feet, estimated to cost approximately $160,000. This structure could be adjacent to or incorporated with the fire station discussed previously.

19. Recreation and Community Facilities

Provision is made in the community development plans for adequate open space and outdoor recreation areas. These recreation areas would be adjacent to the school site and dual use could be made of any facilities provided there. Since this area would require filling, grading and gravel surfacing to make it useable, funds in addition to those provided for the school would be necessary. It is estimated that this work would cost approximately $10,000. While less landfill would be required in the new community area of Design Concept 3 than in the existing townsite more grading would be necessary to provide level ground because of the slope of the site, and costs would approximately be equal.

The recently completed Community Hall, while centrally located for the present community, should be relocated

in the future to a site in the center of the developing community. Relocation of this structure, together with site preparation and pile foundation, is estimated to cost approximately $50,000.

20. Proposed Development Programs

a. General

Construction of the improvements proposed above would be preceded by a series of engineering studies, investigations and design. These engineering activities, together with the proposed improvements, form the proposed development programs which follow.

b. Design Concept 1-1A

1) Engineering Studies and Investigations.

(a) Water supply: location of damsite; geotechnical investigations; preliminary design.

(b) Water treatment: preliminary design; site investigation.

(c) Sewage disposal: preliminary design; site investigation.

(d) Utility study: water distribution and sewage collection; utilidor systems.

(e) Subdivision soils investigation.

(f) Topographic mapping of existing townsite and overflow area.

2) Design.

(a) Improvement of surface drainage in existing townsite.

(b) Water supply and treatment plant.

(c) Sewage disposal, including pumping stations, outfall line and force mains.

(d) Planning and design of subdivisions in existing townsite including streets and utilities. To be done in phases to suit development needs.

(e) Planning and design of overlow area, as above.

(f) Design of public facilities.

(g) Legal surveys, in development phases.

3) <u>Construction</u>

(a) Improvement of surface drainage in existing townsite.

(b) Water supply and treatment plant.

(c) Sewage disposal, pumping stations and mains.

(d) Subdivisions, including streets and utilities, in development phases. First phase to be ready by 1976.

(e) Water and sewer mains for overflow area.

(f) Public facilities.

c. <u>Design Concept 2</u>

1) <u>Engineering Studies and Investigations</u>

(a) Water supply: location of damsite; geotechnical investigations; preliminary design.

(b) Water treatment: preliminary design; site investigation.

(c) Sewage disposal: preliminary design; site investigation.

(d) Utility study: water distribution and sewage collection; utilidor systems.

(e) Subdivision soils investigations.

(f) Topographic mapping.

(g) Selection of site for airport relocation; soils investigations and mapping (by M.O.T.)

2) <u>Design</u>

(a) Improvement of surface drainage in existing townsite.

(b) Water supply and treatment plant.

(c) Sewage disposal, including pumping stations and mains.

(d) Planning and design of subdivisions in existing townsite, including streets and utilities. To be done in phases to suit development needs.

(e) Planning and design of subdivision in airport area, as above.

(f) Design of public facilities.

(g) Legal surveys, in development phases.

(h) Design of new airport (by M.O.T.)

3) Construction

(a) Improvement of surface drainage in existing townsite.

(b) Water supply and treatment plant

(c) Sewage disposal, pumping stations and mains.

(d) Subdivisions, including streets and utilities, in development phases. First phase to be ready by 1976.

(e) New airport (by M.O.T.)

(f) Public facilities

d. Design Concept 3

1) Engineering Studies and Investigations.

(a) Water supply: location of damsite; geotechnical investigations; preliminary design.

(b) Water treatment: preliminary design; site investigation.

(c) Sewage disposal: preliminary design; site investigation.

(d) Utility study: water distribution and sewage collection; utilidor system.

(e) Detailed soils investigation of new community area; final selection of site.

(f) Topographic mapping of new community area.

(g) Study of existing buildings; selection of those suitable for movement to new community site; planning for movements

2) Design

(a) Water supply and treatment plant.

(b) Sewage disposal, including outfall line.

(c) Planning and design of subdivisions in new community area, including streets and utilities. To be done in phases to suit development needs.

(d) Legal surveys, in development phases.

(e) Design of public facilities.

3) Construction

(a) Water supply and treatment plant.

(b) Sewage disposal and outfall main

(c) Subdivisions, including streets and utilities, in development phases. First phase to be ready by 1976.

(d) Public facilities.

1X. RECOMMENDED DEVELOPMENT PROGRAMS

Proposed development programs have been presented for each of three alternative design concepts for the future development of Norman Wells. It is recommended that, after a decision has been reached to adopt one or another of these alternatives, the corresponding development program, essentially as described herein, be accepted and adopted as a guide. This program will provide for the orderly growth and development of the community during the period of expansion which is expected to occur within the next several years.

It has been shown, through population projections based on reasonable prediction of economic growth, that the population of Norman Wells may be expected to increase to approximately 1,400 by 1983, and that further growth to between 2,000 and 3,000 should be anticipated by 1993.

The recommended development programs will provide an improved water supply system, with adequate flows and pressure for fire protection. A sewage treatment and disposal system will be installed, with a collection system serving the entire community. Subdivisions will be provided in increments to accommodate expected growth in demand for residential lots, complete with necessary roads and utilities. New schools will be provided as needed; a fire station and municipal shops and offices will be constructed; surface drainage will be improved; and outdoor recreation areas will be created.

The schedules of funds requirements to accomplish the recommended development programs, for the period through 1983, are contained in the Program Forecasts which follow.

X. PROGRAM FORECASTS

A. Design Concept 1-1A

DESCRIPTION	NORMAN WELLS PROGRAM — $(000's)									
	TOTAL	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-93
UTILITIES - WATER										
Soiltesting and Investigations	70	70								
Engineering and Design	105	70	15	10						10
Construction	(1,735)		(500)	(585)						(650)
Water Supply Dam, etc.	560		300	260						
Water Treatment Plant	600		200	250						150
Water Main, Existing Townsite	75			75						
Water Main, Overflow Area	500									500
UTILITIES - SEWER										
Soiltesting and Investigations	35	25								10
Engineering and Design	60	40	6	4						10
Construction	(965)		(415)	(200)						(350)
Sewage Disposal Facilities	200		200							
Sewer Mains, Existing Townsite	415		215	200						
Sewer Outfall, Overflow Area	350									350
SUBDIVISIONS										
Number of Lots	611	25		174					118	294
Soiltesting and Investigations	320	105					60			155
Mapping	110	60								50
Engineering and Design	530	100	35	35			59	21	20	260
Legal Surveys	110	5		30					20	55
Construction	(10,742)	(559)	(2,074)	(1,840)				(1,409)	(1,250)	(3,610)
Roads and Streets	1,543	94	456	222				312	153	306
Landfill, Existing Townsite	3,500	250	870	870				590	590	330
Clearing & Grading, Overflow Area	444									444
Utilidor	5,255	215	748	748				507	507	2.530
MISCELLANEOUS										
Engineering and Design	76	41	8	16	7	3	1			
Construction	(762)	(75)	(287)	(150)	(133)	(67)	(50)			
Sanitary Landfill	10	10								
Surface Drainage	15	15								
Fire Station and Equipment	85	50	35							
Elementary School	432		252	150	30					
Municipal Building	160				93	67				
Recreation Facilities	10				10					
Relocate Community Hall	50						50			
SUBTOTALS										
Mapping and Legal Surveys	220	65		30					20	105
Soiltesting and Investigations	425	200					60			165
Engineering and Design	771	251	64	65	7	3	60	21	20	280
Construction	(14,204)	(634)	(3,276)	(2,775)	(133)	(67)	(50)	(1,409)	(1,250)	(4,610)
Utilities - Water	1,735		500	585						650
Utilities - Sewer	965		415	200						350
Subdivisions	10,742	559	2,074	1,840				1,409	1,250	3.610
Miscellaneous	762	75	287	150	133	67	50			
TOTALS	15,620	1,150	3,340	2,870	140	70	170	1,430	1,290	5,160

B. Design Concept 2

DESCRIPTION	NORMAN WELLS PROGRAM – $(000's)									
	TOTAL	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-93
UTILITIES - WATER										
Soiltesting and Investigations	50	50								
Engineering and Design	74	50	10	10						4
Construction	(1,235)		(500)	(585)						(150)
Water Supply Dam, etc.	560		300	260						
Water Treatment Plant	600		200	250						150
Water Main	75			75						
UTILITIES - SEWER										
Soiltesting and Investigations	28	28								
Engineering and Design	40	30	5	3						2
Construction	(675)		(415)	(200)						(60)
Sewage Disposal Facilities	200		200							
Sewer Mains	475		215	200						60
SUBDIVISIONS										
Number of Lots	611	25		174					118	294
Soiltesting and Investigations	332	108					60			164
Mapping	110	60								50
Engineering and Design	556	100	35	35			59	21	20	286
Legal Surveys	110	5		30					20	55
Construction	(11,062)	(523)	(1,910)	(1,761)				(1,289)	(1,200)	(4,379)
Roads and Streets	1,307	58	292	143				192	103	519
Landfill, Existing Townsite	4,500	250	870	870				590	590	1,330
Utilidors	5,255	215	748	748				507	507	2 530
MISCELLANEOUS										
Engineering and Design	76	41	8	16	7	3	1			
Construction	(762)	(75)	(287)	(150)	(133)	(67)	(50)			
Sanitary Landfill	10	10								
Surface Drainage	15	15								
Fire Station and Equipment	85	50	35							
Elementary School	432		252	150	30					
Municipal Building	160				93	67				
Recreational Facilities	10				10					
Relocate Community Hall	50						50			
SUBTOTALS										
Mapping and Legal Surveys	220	65		30					20	105
Soiltesting and Investigations	410	186					60			164
Engineering and Design	746	221	58	64	7	3	60	21	20	292
Construction	(13,734)	(598)	(3,112)	(2,696)	(133)	(67)	(50)	(1,289)	(1,200)	(4,589)
Utilities - Water	1,235		500	585						150
Utilities - Sewer	675		415	200						60
Subdivisions	11,062	523	1,910	1,761				1,289	1,200	4 379
Miscellaneous	762	75	287	150	133	67	50			
TOTALS	15,110	1,070	3,170	2,790	140	70	170	1,310	1,240	5,150

C. Design Concept 3

DESCRIPTION	NORMAN WELLS PROGRAM — $(000's)									
	TOTAL	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-93
UTILITIES - WATER										
Soiltesting and Investigations	46	46								
Engineering and Design	70	50	10	7						3
Construction	(1,160)		(500)	(510)						(150)
Water Supply Dam, etc.	560		300	260						
Water Treatment Plant	600		200	250						150
UTILITIES - SEWER										
Soiltesting and Investigations	22	22								
Engineering and Design	38	30	5	3						
Construction	(550)		(400)	(150)						
Sewage Disposal Facilities	200		200							
Sewer Outfall	350		200	150						
SUBDIVISIONS										
Number of Lots	696	25		174		85			118	294
Soiltesting and Investigations	282	80		35			50			117
Mapping	95	50								45
Engineering and Design	470	70	35	30	37	20	49	16	15	198
Legal Surveys	95	3		24		12			16	40
Construction	(9,424)	(293)	(1065)	(985)	(533)	(1,118)	(610)	(714)	(659)	(3,447)
Roads and Streets	987	35	165	82	80	40		112	55	418
Clearing and Grading	1,183	42	148	148	75	70		100	100	500
Relocate Existing Housing	1,220					610	610			
Relocate Existing Mobile Homes	48					48				
Utilidors	5,986	216	732	755	378	350		502	504	2,529
MISCELLANEOUS										
Engineering and Design	76	41	8	16	7	3	1			
Construction	(812)	(75)	(287)	(150)	(133)	(67)	(100)			
Sanitary Landfill	10	10								
Surface Drainage	15	15								
Fire Station and Equipment	85	50	35							
Elementary School	432		252	150	30					
Municipal Building	160				93	67				
Recreation Facilities	10				10					
Relocate Community Hall	100						100			
SUBTOTALS										
Mapping and Legal Surveys	190	53		24		12			16	85
Soiltesting and Investigations	350	148		35			50			117
Engineering and Design	654	191	58	56	44	23	50	16	15	201
Construction	(11,946)	(368)	(2,252)	(1,795)	(666)	(1185)	(710)	(714)	(659)	(3,597)
Utilities - Water	1,160		500	510						150
Utilities - Sewer	550		400	150						
Subdivisions	9,424	293	1,065	985	533	1,118	610	714	659	(3,447)
Miscellaneous	812	75	287	150	133	67	100			
TOTALS	13,140	760	2,310	1,910	710	1,220	810	730	690	4,000

XI. COST COMPARISON OF ALTERNATIVE DESIGN CONCEPTS

A. General

Three alternative design concepts have been presented in Section IX, and are illustrated on Plates 4 through 6. Proposed improvements and approximate cost estimates have been provided for each of these alternatives. These costs are summarized below to allow an order-of-magnitude comparison of the overall costs for the various alternatives.

B. Design Concept 1-1A

1.	Water supply dam, pumphouse and supply main to treatment plant:	$560,000
2.	Water treatment and pumping plant:	600,000
3.	Water distribution main, existing townsite:	75,000
4.	Water supply main and booster pump station, overflow area:	500,000
5.	Sewage disposal facilities:	200,000
6.	Sewer mains and pumping stations, existing townsite:	415,000
7.	Sewer outfall line, overflow area:	350,000
8.	Utilidors; 611 lots at $8,600 per lot:	5,254,600
9.	Local roads and streets, existing townsite, 22,700 feet at $45 per foot:	1,021,500
10.	Main collector loop road, overflow area, 6,400 feet at $35 per foot:	224,000
11.	Local roads and streets, overflow area, 11,900 feet at $25 per foot:	297,500
12.	Landfill, existing townsite, 350 lots at $10,000 per lot:	3,500,000
13.	Site clearing and grading, overflow area, 261 lots at $1,700 per lot:	443,700
14.	Sanitary landfill preparation:	10,000
15.	Fire station and equipment:	85,000

16.	Surface Drainage improvements, existing community:	$ 15,000
17.	Elementary school:	432,000
18.	Municipal building:	160,000
19.	Recreation facilities:	10,000
20.	Relocation of Community Hall:	50,000
	Total Estimated Cost:	$14,203,300

C. Design Concept 2

1.	Water supply dam, pumphouse and supply main to treatment plant:	$ 560,000
2.	Water treatment and pumping plant:	600,000
3.	Water distribution main:	75,000
4.	Sewage disposal facilities:	200,000
5.	Sewer mains and pumping stations:	475,000
6.	Utilidors; 611 lots at $8,600 per lot:	5,254,600
7.	Local roads and streets, existing townsite, 25,000 feet at $45 per foot:	1,125,000
8.	Local roads and streets, airport area, 12,100 feet at $15 per foot:	181,500
9.	Landfill, existing townsite, 450 lots at $10,000 per lot:	4,500,000
10.	Sanitary landfill preparation:	10,000
11.	Fire station and equipment:	85,000
12.	Surface drainage improvement, existing community:	15,000
13.	Elementary school:	432,000
14.	Municipal building:	160,000
15.	Recreation facilities:	10,000
16.	Relocation of Community Hall	50,000
	Total Estimated Cost:	$13,733,100

D. Design Concept 3

1.	Water supply dam and appurtenances:	$ 560,000
2.	Water treatment and pumping plant:	600,000

3.	Sewage disposal facilities:	$ 200,000
4.	Sewer outfall:	350,000
5.	Utilidors, new housing; 611 lots at $8,600 per lot:	5,254,600
6.	Utilidors, relocated existing housing; 85 lots at $8,600 per lot:	731,000
7.	Relocation of existing housing;	
	61 buildings at $20,000 each:	1,220,000
	24 trailers at $2,000 each:	48,000
8.	Main collector loop road, 9,200 feet at $35 per foot:	322,000
9.	Local roads and streets, 26,600 feet at $25 per foot:	665,000
10.	Site clearing and grading, 696 lots at $1,700 per lot:	1,183,200
11.	Sanitary landfill preparation:	10,000
12.	Fire station and equipment:	85,000
13.	Surface Drainage improvement, existing community:	15,000
14.	Elementary school:	432,000
15.	Municipal building:	160,000
16.	Recreation facilities:	10,000
17.	Relocation of community hall:	100,000
	Total estimated cost:	$11,945,800

E. Summary

Arranged in order of their estimated costs, the three design concepts are as follows:

Design Concept	Estimated Cost
1-1A	$14,203,300
2	$13,733,100
3	$11,945,800

However, implementation of Design Concept 2 would require an

expenditure of approximately $6,000,000 for relocation of the airport. From a cost standpoint alone, this would remove this plan from consideration. Thus, the comparison would logically be between Design Concepts 3 and 1-1A.

XII. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

A. Discussion

This report has presented the economic background which establishes the factors stimulating the growth of the community of Norman Wells. It has analyzed the population growth anticipated in connection with various developments and circumstances. It has estimated the physical space requirements of the community to accommodate the expected growth. And it has considered the alternative forms of community which may be developed to cope with the expected growth.

Because of the physical space limitations of the present townsite, bounded as it is by the Mackenzie River and by other existing facilities, and because of the poor foundation conditions of the area remaining for expansion, it was apparent that the alternative of establishing a new site for the community should be thouroughly considered. An office airphoto study of the surrounding area was made to identify all potential sites for a new community. Of the several possible sites thus located one was selected which provided the best balance between the factors of accessibility, convenience to transportation and industrial facilities, and favourable foundation conditions. A preliminary soils investigation of this site was then conducted, which verified that it is apparently suitable for the development of a new community.

Three alternative design concepts have been proposed, two based upon full development of the existing townsite with eventual overflow either into a new and separate area or into the area presently occupied by the airport, and the third based upon immediate development of a new community site. The pros and cons of each alternative have been presented and the possible forms of development illustrated. Recommended programs of development

have been presented for each alternative and approximate costs have been provided. Program forecasts have also been provided for each alternative to indicate the range of expenditures required in the period through 1983 to implement the development program for whichever design concept may be adopted.

B. Conclusions

It is concluded that the most favourable concept for continued development and expansion of Norman Wells would be the establishment of a completely new site for residential and ancillary community development. The new site would provide aesthetic advantages, would be properly related to the highway, and would be isolated from any airport interference. Adequate room would be available for unlimited expansion, and the community could be planned to provide proper relationships between its various parts.

Because Norman Wells is not an old established community and because most of the populace is relatively new, there is little attachment to the present site. Since most of the land and buildings are under government control the problems of implementing a move to a new site should be relatively minor. As new water and sewer utilities will be required in any event, they could best be established in an area which would allow ample room for future expansion. The area now occupied by residential buildings would be most suitable for light industrial uses, and the availability of utilities should make the area readily saleable.

Better foundation conditions in the proposed new site would allow construction of buildings, streets and utilities at the lowest possible cost. The ultimate cost to develop the community to accommodate the anticipated growth in the next twenty years would be lower under the proposed concept than any other.

Engineering studies, topographic mapping and detailed soils

investigations of the proposed new site should be undertaken as soon as possible to better define its location and to establish parameters for design. Planning and design of utilities and streets should follow at an early date, and construction should commence on a schedule which would allow initial residential occupancy no later than 1976.

C. Recommendations

Based upon the findings presented in this report it is respectfully recommended:

1. That Design Concept 3, the new community, essentially as presented herein, be accepted and adopted as the approved development plan for the continued expansion of Norman Wells.

2. That the development program for Design Concept 3, essentially as described herein, be accepted and adopted as a guide for the orderly growth and development of the community.

3. That the land use and development controls, essentially as presented herein, be adopted and rigourously enforced to control all development in the community.

4. That detailed investigations, planning and design studies be undertaken as soon as possible and that construction of improvements be commenced on a schedule which would allow initial residential occupancy of the new community no later than 1976.

APPENDIX "A"

TERMS OF REFERENCE

Proposed Terms of Reference for the Development Plans

The content of the plan will consist of the basic items outlined below. It will be in report form with text, diagrams and plans to fully support the recommendations and estimates which will be made. All information on pipeline and highway impact will be available to the consultant and he is whenever possible expected to prevent the duplication of effort with the use of such information (i.e. much or all the information asked for in No. 1, a,b,c, under planning analysis will be contained in impact reports currently underway).

A. Base Map Preparation

The Consultant shall update the existing Site Plans based on the latest aerial photography to indicate new structure or buildings since added. The base maps will be used by the Consultant for remainder of surveys and studies. The consultant will also prepare such area base maps as required to carry out the intent of the Study (i.e. a map showing the extent of Commissioner's Land and conservation requirements therein).

A detailed breakdown of mapping costs is included in Appendix B.

B. Existing Conditions Analysis

1. Planning Analysis -

(a) Economic - Information on income, availability and skill of labour, employment opportunities, the resource base and development opportunities will be analyzed and used as a basis for proposed physical expansion. This information will have a bearing on future population forecasts.

(b) Social - Utilizing information obtained in the economic analysis plus additional existing information, the Consultant shall examine existing data on social conditions as related to schools, recreation, housing and health.

(c) Demographic - An analysis of the existing population data by age groups, sex, family formulation, size, etc. shall be undertaken. Past population trends shall be studied and related to anticipated growth and population projections made on a twenty (20) year basis. These projections will relate to economic considerations. The land and facility allocations for the projected population shall be determined and shall serve as a primary factor in preparing future community plans.

(d) Municipal viability survey - An analysis of the physical and economic condition of the community as related to the communities ability to finance the required and proposed municipal services will be required. This will be done within the context of existing grant and capital works policies.

(e) Existing Housing Survey - Surveys shall be conducted to determine existing housing conditions, life expectancy, etc., through on-site inspection and by review of recent reports and information available.

Land Use Considerations

(a) Land use - An on-site inspection will be conducted to accurately determine existing land uses for all appropriate land use categories.

(b) Land Tenure - A survey of existing data on leases and land utilization shall be made for both the public and private sector.

(c) Land Requirements - Existing agencies, and private groups, shall be surveyed for their estimated future land requirements based on existing or anticipated programs. This land requirement input, along with the Economic, Social and Demographic Analyses shall provide the basis for proposed land use allocations in long range plans for the Community. Constraints of cost, terrain, weather, servicing capability and environmental factors will also be utilized to establish the framework of this plan.

(d) Natural & Man-Made Factors - Based on existing studies, air photo interpretation, existing mapping and on-site inspection, natural features covering soils, mineral deposits, permafrost conditions, topography, drainage, weather, wind direction, etc., shall be examined by the consultant. In addition, man-made features shall be noted (much of this information shall be obtained from the existing land use survey) with particular attention given to air strips, roads and shoreline facilities. Both the natural and man-made features combined with the information gathered in the foregoing sections, shall be utilized by the Consultant in establishing future land use patterns.

3. <u>Engineering Analysis - Services and Facilities</u>

(a) Inspection of Existing Services and Facilities - Inspect existing services and facilities (water supply and distribution, sewage collection, garbage, electricity, etc.) with particular emphasis on costing existing methods of operations and providing specific and general comments on same. The N.W.T. Territorial Water and Sanitation Policy establishes criteria in this regard.

(b) Comparison of Servicing Alternatives - Provide for general examination of various servicing methods appropriate and suitable for the community.

(c) Sewage Disposal and Garbage Disposal - Provide for examination and evaluation of existing sewage disposal and garbage disposal methods, and where appropriate include recommendations for improvements (present and future).

(d) Roads - Make recommendations on road construction standards appropriate for the community (present and future).

(e) Surface Drainage - Provide a surface drainage scheme for the community including recommendations on channel improvements, sizing and location.

(f) Soils Information - Provide soils information suitable for use in identifying areas which can be most economically developed and for purposes of subdivision design to encompass those areas which might be developed within the next 7 years.

(g) Granular Material Services - Use the Granular materials report to identify and zone granular deposits.

C. Plan Preparation

1. Concept Plan - The Consultant shall prepare a conceptual plan of land use, roads and community facilities. This plan shall indicate general land expansion requirements and suggested phasing. Possible alternate approaches to future development shall be examined in this document.

2. Land Use Plan - Based on the Concept Plan the Consultant shall prepare a Land Use Plan and Report setting forth those recommendations (upon adoption) which shall guide public and private development and administration on a twenty (20) year basis. A special section in this report will note the

problems and staging for community development, should it appear that a boom period will last only during highway and pipeline development.

3. Implementing By-Laws or Orders - The Consultant shall prepare Zoning recommendations consistent with the policies and land use categories of the plan for review and adoption.
4. Subdivision Design - The Consultant shall prepare a plan of subdivision for the existing community development where required and a plan of subdivision for the development anticipated in the next seven years.

D. Housing and Building Standards Program

1. Housing Needs - The existing housing survey will be related to projected needs and recommendations will be made to provide for these needs through government programs or private enterprise. In this regard the Task Force report on housing should be consulted. A special section will be required on projections of housing mix (includes program to suit family structures and unit densities) and its effects on the community with emphasis on the impact of mobile homes on the community's future development and its impact as a revenue producing source.
2. Building Adaptations - Servicing Requirements and Cost Estimates - indication of building adaptations which may be required for ease of servicing with related cost estimates.

E. Cost Estimates

1. Municipal Services - Program Phasing - cost estimates for recommended improvements and expansion services. Provide recommendations on phasing for items requiring expenditures of capital funds. Recommend a 7-year capital works program. A special reference should be made again to effects on capital requirements during the anticipated boom period.

2. Provide cost estimates for Operation and Maintenance (including manpower) requirements due to program recommended in number one above.
3. Cost Estimates - Systems & Facilities - This section should include other public facilities that may be needed, i.e. schools, roads, recreation sites, etc.

F. <u>General</u>

(a) Contact will be made and maintained with the Community Councils to ensure their input is obtained and their requirements fully determined.

(b) Personal contact with local groups, agencies, firms will also be established to determine their requirements.

(c) Contact with other government and private agencies concerned will be made to determine their future development requirements and expansion possibilities or other particular interests. These will include Territorial Government officials, Federal Government officials and private groups. Most of this information will be available in impact studies currently being prepared.

(d) Preparation of a draft report, for distribution by the Government of the Northwest Territories, will be made to enable circulation. Replies and comments to be returned at any early date.

The final general development plan would be prepared immediately upon completion of analysis of all circulation replies and discussions.

APPENDIX "B"

POPULATION AND EMPLOYMENT

Technical Appendix: Population and Employment

The population levels of Norman Wells have been largely determined by economic conditions, external to the community itself. In the past people have located in the settlement mainly for employment reasons, and the term of employment has often been less than two years. For this reason the population has had little opportunity to stabilize and thus there has not been substantial internal growth. The population has fluctuated between 350 to 450 persons. In early 1973 the total permanent population was 444 plus approximately 100 transients. Considering the permanent population the ratio between males and females between the ages of 20 and 55 is approximately 1.7:1. This indicates that the town attracts males for its employment opportunities. Since population and employment are so closely related in this settlement the present employment situation will be considered. The following table lists the employers in the settlement and the number of employees.

Table 1 Employment - Permanent

Employer	Male	Female	Total	Part-time
Alpine Helicopter	2		2	
CNT	2		2	
Contact Airways	1	1	2	
Mid Auto Transportation	5		5	
Nahamn Air Services	6	1	7	1
Namion Taxi	1		1	
General Store	2	2	4	1
Norman Wells Transportation	14	1	15	
NCPC	3		3	1
Northern Helicopter	3		3	
Pe Ben Trucking	2		2	
Northwood Airlines	3		3	
Okanagan Helicopter	3		3	
RCMP	1		1	
Nursing Station		2	2	2
DPW	2		2	
Education	1	2	3	
Environment Canada	5		5	
Ministry of Transport	27	1	28	
Transwestern	1		1	
Imperial Oil	30	1	31	
Forezs	3	1	4	
Bulls	2	1	3	
Mackenzie Mt. Service Station	8	1	9	
Mackenzie Mt. Lodge	3	14	17	2
PWA	3		3	1
Lands and Forest	2	1	3	2
Bank	1	1	2	
Administration	1		1	1
TOTAL	137	30	167	11

Seasonal Employment

Employer	Total	Season (if applicable)
Alpine Helicopter	4	
Norman Wells Transportation	25	
Pre Cambrian Mining	30	Winter
NTCL	20	Summer
Fisheries	5	Summer
Dietz Trucking	7	Winter
Imperial Oil (barrel reconditioning)	16	Summer
Imperial Oil (clean-up)	7	
Lands and Forest	9	
	123	

There are approximately 167 full-time permanent positions in the settlement of Norman Wells. In 1974 employment is expected to increase by 7%; employers are making arrangements to hire approximately 13 new permanent employees. In addition to permanent employment, there is seasonal employment. This seasonal employment is very important; for example the Northern Transportation Company employs 20 people for the season, May to October. Imperial Oil employs 7 men for approximately 10 months for clean-up operations, plus another 16 men during the summer months for barrel reconditioning. The Fishery Department employs five men during the summer months. In the summer there are approximately 50 men seasonally employed. In the winter months other types of employment opportunities appear. Pre-Cambrian Mining employs up to 30 men during winter operations. Dietz Trucking employs approximately seven people in the winter. In addition to these jobs there are construction activities, explorations, and other short term

employment. There are about the same number of seasonal jobs in the winter and summer; however, these are not necessarily filled by the same men and many of the employees are transient workers. There may be up to 100 transients in the settlement at any given time.

As discussed in the main report, Norman Wells is in a position to act as an important transportation and service centre in light of the developments that are taking place in the North. If these opportunities are taken advantage of (i.e. if proper facilities are provided in the community which enhance the quality of the Town) Norman Wells should experience considerable growth. We, therefore, examined the effects of development in terms of employment opportunities.

During construction of the pipeline there will be 6,000 men or more employed by the third and fourth year of construction. Each construction base camp would accommodate approximately 700 men. They would be involved in clearing rights-of-way, grading and levelling, ditching, line assembly, replacement, and finally right-of-way restoration. The construction phase may result in pressure on the existing town, although the construction personnel will not become part of the permanent population. They will live in camps and later move away after completion of the construction. However, the town should be able to benefit from the boom during the construction phase.

The settlement of Norman Wells will be able to act as a transportation and service centre. Pipeline employment will increase the income of the community and make it more financially feasible for businessmen to establish proper facilities for the community.

However, it must be kept in mind that many of these workers will be temporary and thus the town must not over-step itself. Rather, the town must base its long range plans upon what may be expected to be permanent population levels.

Due to pipeline construction there will be a major impact felt on the transportation industry. The employment figure for direct handling is 400 men* during the peak, which would occur around 1980 providing construction started in 1977. In addition there would be about an equal number of men as support staff. Assuming that there are four operational centres, this would mean a peak support staff of 100 men per regional centre. Some of the support staff would be permanent and probably be in the community for some length of time. If the community offered proper facilities, some of these jobs would be filled by permanent household heads. After the construction phase, Norman Wells could remain an important transportation centre. With the construction of the highway, Norman Wells would have expanded functions as a transportation centre. For projection purposes, we assumed half of these jobs to be permanent (i.e. fifty employees).

After construction is completed, there will be men required for operation and maintenance. There will be three main centres for pipeline operation, the two largest being at Fort Simpson and Inuvik. The third centre would be at a mid-way point and employ approximately fifty men. In addition to direct jobs created by the pipeline operation, there will be an increase in production activity. There will also be men employed in the continued construction activities associated with the pipeline. For projection purposes it is assumed that Norman Wells is selected as

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* Mr. Hodgson, Territorial Commissioner

the third centre and that the number of jobs resulting amounts to 60.

After completion of the Mackenzie Highway, there will be men employed in maintenance of the road. If construction starts in 1975 the Mackenzie Highway should be completed in 1977-1978. These figures for maintenance employment are included in the 1978 population projection. Norman Wells will probably be a maintenance centre from which crews can work in both directions. It is estimated that these crews will amount to approximately 20 workers to cover a span of fifty miles in each direction from Norman Wells.*

The construction of the gas line will have an expansionary effect on Norman Wells. However, in addition to the gas reserves in the North, there are also vast oil reserves. With the huge national and international requirements for fuel, the oil in these reserves will be in great demand and there must be a means to get the product to market.

Presently there is a proposal for an oil pipeline from Prudhoe Bay to Edmonton. The construction and operation of an oil pipeline appears to be similar to that for the gas line. The construction would peak at approximately 8,000 employees, similar to that of the gas line. A permanent operating organization of 600 to 700 employees is estimated. Some of these positions will be in Edmonton and Fairbanks. District offices would probably be at Fort McPherson, Norman Wells and Fort Simpson. It will be assumed that the regional centre at Norman Wells will employ a similar number of men to the gas line centre. This will result in fifty employees at Norman Wells. It has been suggested** that an oil line could

* Interview with Mr. J. R. Bentley, N.W.T. Department of Public Works.

** Dr. Reed of the U.S. Geological Survey.

follow the operation of a gas line by two years. Other sources are less optimistic and it is difficult to place a time period upon these events, but by 1988 it is probable that an oil line will be in operation.

During the construction of the gas line and highway the transient population will show an increase. As discussed earlier there will be temporary transportation workers. It has been estimated that 50 transportation workers are permanent and there will be 100 transient transportation workers. In the construction base camp there will be approximately 700 men. Although it may be the aim of the contractor to provide accommodation in the base camp, some workers will probably live in the town if accommodation can be found there. In any event, higher-ranking officials may seek accommodation in the town as they inspect and coordinate the work. It is assumed, therefore, that 5 percent of the construction workers are temporary residents in the town. Presently the seasonal employment equals approximately 11 percent of the permanent population. A large portion of the transient population is employed in exploration and related seasonal employment. As activities in the north expand these types of jobs will increase in number. For projecting future population it is assumed that a similar proportion (i.e. 11% of permanent population) will also form part of the transient population engaged in such activities.

In addition to the aspects considered above there will be expansionary effects of tourism and providing services for travellers. In 1972, private vehicles formed 28 percent of those using the Liard River ferry near Fort Simpson. During the same year, 4,620 passengers arrived at Norman Wells via airplane; assuming a party size of two yields 2,310 groups requiring accommodation.

If air traffic increases by 5 percent in the next five years, and the number of private vehicles that reached Fort Simpson now reach Norman Wells, the total number of groups requiring accommodation will be 5,295. It will be assumed that each group stops for four days and that the peak of travel occurs over a seven-months' period. In addition accommodation will be required for those transients employed in exploration and related activities. For example, in 1978 there could be 88 such people. Assuming that 70 percent stay in hotels and assuming two per room, 30 hotel units will be required. One hundred units are required in 1978 for the travellers. Presently there are 29 units in Norman Wells resulting in employment for 17 people. These extra units will result in employment for 52 people in 1978. The nature of employment in hotels and motels is such that a high percentage of females is employed. Due to this fact the number of employees will be added to the population rather than applying a multiplier effect. After 1978, the highway will be completed and the exploration activities will increase the number of travellers. Thus the number of travellers is assumed to increase at the rate of 5 percent per annum after 1978.

For projection purposes it will be assumed that the ratio between basic and non-basic workers (i.e. service) is 1:0.5 and that 70 percent of the workers are married. These married workers are assumed to have a family of three dependents (the average family size in the N.W.T. is four).

Using the foregoing estimates and assumptions, the following shows the population projection:

Projected Population for 1978:

Permanent Population

Additional Permanent Workers:

Road Maintenance	20		
Transportation	50		
Total Basic Workers	70		
Non-Basic Workers	35		
TOTAL WORKERS	105		
Married Workers	73 x 4	=	292
Single Workers	32	=	32
Travel Service Workers	52	=	52
			376

1974 Permanent Population	444
Additional Population	376
	820

Transient Population

Present Transient	100	
Construction Workers	35	(5% of 700)
Transportation Workers	100	
Exploration & Related Seasonal	88	
	323	

Total Population

820 + 323 = 1,143

Projected Population for 1983:

Permanent Population

Additional Workers:

Pipeline	60				
Non-Basic	30				
	90				
Married Workers	63	x	4	=	252
Single Workers	27			=	27
Travel Service Workers	13			=	13
					292

1978 Permanent Population	820
Additional Population	292
	1,112

Transient Population

Present Transient	100
Transportation	50
Exploration & Related Seasonal	120
	270

Total Population

1,112 + 270 = 1,382

Projected Population for 1988:

Permanent Population

Oil Line Employment	50				
Transportation Workers	50				
Basic Workers	100				
Non-Basic Workers	50				
TOTAL WORKERS	150				
Married Workers	105	x	4	=	420
Single Workers	45			=	45
Travel Service Workers	16			=	16
					481

1983 Permanent Population	1,112
Additional Population	481
	1,593

Transient Population

Present	100
Transient	50
Exploration & Related Seasonal	170
	320

Total Population

1,593 + 320 = 1,913

Projected Population for 1993

After 1988, barring any major activities, the only increase in employment is that resulting from 17 additional travel service workers.

Permanent Population	1,610
Transient Population	327
	1,937

Alternative High Population Projection:

Instead of using a basic-to-non-basic worker ratio for the population projection, the number of employees in the service industries could be estimated according to population levels. Each population level requires certain services which are sources of employment. These fall mainly into the category of public and personal services. There is a fairly general relationship between the number of service employees and the population of the community. Based upon the following comparison with other communities the number of non-basic workers can be established.

Bases of Projection:

Municipal:	Standard of Yellowknife 1 employee per 82 residents.
Police:	1 policeman per 600 residents; support staff ratio 80:10.
Power:	Expansion possiblities of N.C.P.C.
School:	22 pupils per 100 population. 1 teacher per 25 pupils plus principal. The figures are based upon total population in order to correlate to total number of students in the community.
Trade:	10,000 square feet to each 1,000 population 1 employee per 200 square feet.
Financial:	2 employees per 70 population.

Service Station: 2 employees per 70 population.

Hospital: 2 staff per bed, 5 beds per 1,000 population.

The high estimate of the projection will use the above method plus an assumption of an internal economic growth of the community. The boom effect of the activities that have been discussed may have a spin-off effect on other activities. It is assumed that there is a growth of 2 percent per annum in the permanent population. This method is used to obtain a high population projection.

1978 Population Projection

Non-Basic Workers	70				
Married	49	x	4	=	196
Single	21			=	21
Travel Services	52			=	52
					269

1973 Permanent Population plus 2% growth per annum	488
Additional Population	269
Population to be Serviced	757

Additional Service Employees - 85 persons

Married	58	x	4	=	232
	27				27
					259
Permanent Population	757	+	259	=	1,016
Transient Population (same as in Method 1)					323
Total Population					1,339

1983 Population Projection

Non-Basic Workers	60				
Married	42	x	4	=	168
Single	18			=	18
Travel Service	13			=	13
					199
1978 Permanent Population plus 2% growth per annum					1,117
Additional Population					199
Population to be Serviced					1,316
Additional Service Workers					73
Married	51	x	4	=	204
Single	22			=	22
					226
Permanent Population	1,316	+	226	=	1,542
Transient					270
Total Population					1,812

1988 Population Projection

Non-Basic Workers	100				
Married	70	x	4	=	280
Single	30				30
Travel Services	16				16
					326
1983 Permanent Population plus 2% growth per annum					1,696
Additional Population					326
Population to be Serviced					2,022
Additional Service Workers	102				
Married	70	x	4	=	280
Single	32				32
					312
Permanent Population	2,022	+	312	=	2,334
Transient Population					320
Total Population					2,654

1993 Population Projection

1988 Permanent Population, plus 17 hotel workers, plus 2% growth per annum = 2,567

Additional Service Workers	30				
Married	21	x	4	=	84
Single	7			=	7
					91
Permanent Population	2,567	+	91	=	2,658
Transient					327
Total Population					2,985

The following table is a summary of the above analysis:

Year	Low Projection	High Projection
1973	544	
1978	1,143	1,339
1983	1,382	1,812
1988	1,913	2,654
1993	1,937	2,985

APPENDIX "C"

WATER QUALITY ANALYSES

ENVIRONMENT CANADA

ENVIRONMENTAL PROTECTION SERVICE

DEPARTMENT OF ENVIRONMENT

ENVIRONMENTAL PROTECTION SERVICE

CHEMICAL ANALYSIS OF WATER

Location: Norman Wells, N.W.T.

Submitted By: P.H.E. Div.

Identifying Marks:

Sampled By: J.W. Grainge

(1) Bosworth Creek

Date Sampled: July 2, 1953

(2)

Date Received in Lab:

(3)

(4)

Constituents in Mg/L	Canada Drinking Water Standards	Sample No. 1
pH	6.5 - 8.3	8.2
Total Hardness (as $CaCO_3$)	>180 Poor	195.9
Total Alkalinity (as $CaCO_3$)	30 - 500	147.0
Iron (Fe), Total	0.3	0.6
Manganese (Mn), Total	0.05	N.D.
Color (Units)	15	c20
Turbidity (JTU Units)	5	N.D.
Nitrate Nitrogen (N)	10	0.033
Sulfate ($SO_4^{=}$)	500	58.8
Fluoride (F^-)	1.2	N.D.
Specific Conductance		N.D.
Total Disolved Solids-Determined		320

Comments:

N.D.: Not Determined

Date: July 20, 1953

Chemist: F.E. Artlett

DEPARTMENT OF ENVIRONMENT

ENVIRONMENTAL PROTECTION SERVICE

CHEMICAL ANALYSIS OF WATER

Location: Norman Wells, N.W.T.

Submitted By: D. Jenkinson

Identifying Marks:

Sampled By: D. Jenkinson

(1) Bosworth Creek

Date Sampled: March 12, 1970

(2)

Date Received in Lab: Mar. 19, 1970

(3)

(4)

Constituents in Mg/L	Canada Drinking Water Standards	Sample No. 2
pH	6.5 - 8.3	7.60
Total Hardness (as $CaCO_3$)	>180 Poor	432
Total Alkalinity (as $CaCO_3$)	30 - 500	202
Iron (Fe), Total	0.3	0.03
Manganese (Mn), Total	0.05	N.D.
Color (Units)	15	<5
Turbidity (JTU Units)	5	0.7
Nitrate Nitrogen (N)	10	0.05
Sulfate ($SO_4^{=}$)	500	228
Fluoride (F^-)	1.2	0.44
Specific Conductance		N.D.
Total Disolved Solids-Determined		638

Comments:

N.D.: Not Determined

Date: April 15, 1970

Chemist: A. Boyko

DEPARTMENT OF ENVIRONMENT

ENVIRONMENTAL PROTECTION SERVICE

CHEMICAL ANALYSIS OF WATER

Location: Norman Wells, N.W.T.

Submitted By: D, Jenkinson

Identifying Marks:

Sampled By: D. Jenkinson

(1) Bosworth Creek

Date Sampled: March 7, 1970

(2) Pumphouse, Raw Water

Date Received in Lab: May 8, 1970

(3)

(4)

Constituents in Mg/L	Canada Drinking Water Standards	Sample No. 3
pH	6.5 - 8.3	8.10
Total Hardness (as $CaCO_3$)	>180 Poor	205
Total Alkalinity (as $CaCO_3$)	30 - 500	128
Iron (Fe), Total	0.3	0.88
Manganese (Mn), Total	0.05	N.D.
Color (Units)	15	90
Turbidity (JTU Units)	5	8.5
Nitrate Nitrogen (N)	10	0.03
Sulfate ($SO_4^=$)	500	70
Fluoride (F^-)	1.2	0.44
Specific Conductance		N.D.
Total Disolved Solids-Determined		318

Comments:

N.D.: Not Determined

Date: May 21, 1970

Chemist: A. Boyko

DEPARTMENT OF ENVIRONMENT

ENVIRONMENTAL PROTECTION SERVICE

CHEMICAL ANALYSIS OF WATER

Location: Norman Wells, N.W.T.

Submitted By: D. Jenkinson

Identifying Marks:

Sampled By: D. Jenkinson

(1) Bosworth Creek

Date Sampled: July 4, 1970

(2) Pumphouse

Date Received in Lab: July 6, 1970

(3)

(4)

Constituents in Mg/L	Canada Drinking Water Standards	Sample No. 4
pH	6.5 - 8.3	8.30
Total Hardness (as $CaCO_3$)	>180 Poor	166
Total Alkalinity (as $CaCO_3$)	30 - 500	150
Iron (Fe), Total	0.3	<0.01
Manganese (Mn), Total	0.05	N.D.
Color (Units)	15	5
Turbidity (JTU Units)	5	0.56
Nitrate Nitrogen (N)	10	0.02
Sulfate ($SO_4^=$)	500	63
Fluoride (F^-)	1.2	0.34
Specific Conductance		N.D.
Total Disolved Solids-Determined		356

Comments:

N.D.: Not Determined

Date: July 23, 1970

Chemist: A. Boyko

DEPARTMENT OF ENVIRONMENT

ENVIRONMENTAL PROTECTION SERVICE

CHEMICAL ANALYSIS OF WATER

Location: Norman Wells, N.W.T.

Submitted By: D. Jenkinson

Identifying Marks:

Sampled By: D. Jenkinson

(1) Bosworth Creek

Date Sampled: Nov.13, 1970

(2)

Date Received in Lab: Nov. 18, 1970

(3)

(4)

Constituents in Mg/L	Canada Drinking Water Standards	Sample No. 5
pH	6.5 - 8.3	7.65
Total Hardness (as $CaCO_3$)	>180 Poor	295
Total Alkalinity (as $CaCO_3$)	30 - 500	167
Iron (Fe), Total	0.3	0.02
Manganese (Mn), Total	0.05	N.D.
Color (Units)	15	<5
Turbidity (JTU Units)	5	0.5
Nitrate Nitrogen (N)	10	0.02
Sulfate ($SO_4^=$)	500	113
Fluoride (F^-)	1.2	0.43
Specific Conductance		N.D.
Total Disolved Solids-Determined		436

Comments:

N.D.: Not Determined

Date: Nov. 25, 1970

Chemist: A. Boyko

DEPARTMENT OF ENVIRONMENT

ENVIRONMENTAL PROTECTION SERVICE

CHEMICAL ANALYSIS OF WATER

Location: Norman Wells, N.W.T.

Submitted By: J.W.Grainge

Identifying Marks:

Sampled By: A. Taylor

(1) Bosworth Creek

Date Sampled: July 19, 1971

(2)

Date Received in Lab: Aug. 3, 1971

(3)

(4)

Constituents in Mg/L	Canada Drinking Water Standards	Sample No. 6
pH	6.5 - 8.3	8.0
Total Hardness (as $CaCO_3$)	>180 Poor	246
Total Alkalinity (as $CaCO_3$)	30 - 500	166
Iron (Fe), Total	0.3	0.05
Manganese (Mn), Total	0.05	0.01
Color (Units)	15	10.0
Turbidity (JTU Units)	5	1.1
Nitrate Nitrogen (N)	10	0.08
Sulfate ($SO_4^{=}$)	500	78.6
Fluoride (F^-)	1.2	0.16
Specific Conductance		462.0
Total Disolved Solids-Calculated		287.2

Comments:

Date: Aug. 12, 1971

Chemist: R. Horoway

DEPARTMENT OF ENVIRONMENT

ENVIRONMENTAL PROTECTION SERVICE

CHEMICAL ANALYSIS OF WATER

Location: Norman Wells, N.W.T.

Submitted By: W.J. Francl & Assoc.

Identifying Marks:

Sampled By: J. Erickson

(1) Upper Bosworth Creek

Date Sampled: April 18, 1974

(2)

Date Received in Lab: April 24, 197

(3)

(4)

Constituents in Mg/L	Canada Drinking Water Standards	Sample No. 7
pH	6.5 - 8.3	7.6
Total Hardness (as $CaCO_3$)	>180 Poor	471
Total Alkalinity (as $CaCO_3$)	30 - 500	199
Iron (Fe), Total	0.3	0.06
Manganese (Mn), Total	0.05	<0.02
Color (Units)	15	<5
Turbidity (JTU Units)	5	<1
Nitrate Nitrogen (N)	10	<0.10
Sulfate ($SO_4^{=}$)	500	320
Fluoride (F^-)	1.2	0.59
Specific Conductance		950

Comments:

Date: May 9, 1974

Chemist: A. Boyko

APPENDIX "D"

WEATHER DATA

NORMAN WELLS, N. W. T.

WEATHER DATA - 28 YEARS OF RECORD

ELEMENT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Mean Daily Temperature (DEG F)	-19.7	-15.8	-2.0	18.7	41.2	56.6	60.9	55.7	42.5	24.7	-0.6	-14.6	20.6
Mean Daily Maximum Temperature	-12.3	- 7.6	9.1	30.1	51.6	67.1	71.3	65.3	50.2	30.5	5.8	- 7.6	29.5
Mean Daily Minimum Temperature	-27.1	-23.9	-13.0	7.3	30.9	46.0	50.4	46.0	34.8	18.7	-7.0	-21.6	11.8
Extreme Maximum Temperature	44	41	52	64	88	91	89	89	80	68	56	35	91
Extreme Minimum Temperature	-63	-66	-51	-35	1	27	30	21	7	-25	-45	-53	-66
No. of Days with Frost	31	28	31	29	17	1	*	1	11	29	30	31	239
Mean Rainfall	T	0.00	0.01	0.05	0.35	1.41	2.21	2.43	1.11	0.11	0.01	T	7.69
Mean Snowfall	8.4	7.3	5.0	5.3	2.5	0.3	0.0	T	2.3	9.1	8.6	7.6	56.4
Mean Total Precipitation	0.82	0.68	0.49	0.56	0.60	1.44	2.21	2.43	1.33	0.99	0.86	0.76	13.17
Greatest Rainfall in 24 hrs.	T	T	0.22	0.49	0.60	1.44	1.94	1.91	1.06	0.30	0.23	.01	1.94
Greatest Snowfall in 24 hrs.	7.0	8.3	2.9	9.3	8.1	5.9	T	T	6.6	6.1	6.5	6.7	9.3
Greatest Precipitation in 24 hours	0.70	0.77	0.27	0.93	0.81	1.44	1.94	1.91	1.06	0.62	0.65	0.67	1.94
No. of Days with Measurable Rain	0	0	*	*	4	9	11	12	9	2	*	*	47
No. of Days with Measurable Snow	13	12	10	8	4	*	0	0	3	11	14	12	87
No. of Days with Measurable Precipitation	13	12	10	8	7	10	11	12	11	13	14	12	133

APPENDIX "E"

UTILIDOR COST ANALYSIS

UTILIDOR COST ANALYSIS

Trial designs were prepared in preliminary form for a hypothetical subdivision which would be typical of the plans under consideration, as shown on Sheet E-1. Typical sections and preliminary design details for the three alternatives considered are shown on Sheets E-2 through E-4.

The alternatives are as follows:

(1) "Conventional" utilidor system, as used in the most recent utilidor reconstruction at Norman Wells, with gravity sewers.

(2) "Utiliduct" system, with gravity sewers.

(3) "Utiliduct" system, with pressure sewers.

Preliminary cost estimates are summarized on the following pages, and are tabulated below:

Alternative	Cost per Unit
(1)	$8,600
(2)	$6,800
(3)	$7,700

UNIT COST - UTILIDOR WITH GRAVITY SEWERS
Alternative (1)

Line	Length ft.	Utilidor Width in.	Gravity Sewer in.	Sewer Forcemain in.	Water Supply in.	Hot Water in.	Cost $
ABD	950	36	6	6	6	two - 2	128,520
DFG	820	36	6	6	6	two - 2	110,700
FHJ	735	24	6	-	4	two - 2	84,525
DJ	285	36	6	-	6	two - 2	35,625
JMR	1815	24	6	-	4	two - 2	208,725
RSB	500	36	6	-	6	two - 2	62,500
STM	1010	24	6	-	4	two - 2	116,150
Total:	6115					Total:	746,745

Assume 133 single-family units and 27 apartments in 3 buildings;
Total: 160 units.

House connections, 25 feet long at $2,650 each, 151 required;
Total cost: $400,150.

Unit cost for utilidors: ($746,745 + 400,150) /160 = $7,170,
plus approximately 20% for contingencies and engineering = $8,600 per unit

Average cost of utilidors - $122.12 per foot

UNIT COST - "UTILIDUCT" WITH GRAVITY SEWERS
Alternative (2)

Line	Length ft.	Outer Pipe in.	Gravity Sewer in.	Sewer Forcemain in.	Water Supply in.	Hot Water in.	Cost $
AB	500	21	6	6	6	4	63,300
BCD	450	21	6	6	6	3	58,000
DFG	820	21	6	6	6	3	99,500
FHJ	735	18	6	-	4	2	71,940
DJ	285	21	6	-	6	3	29,700
JMR	1815	18	6	-	4	2	180,600
RSB	500	21	6	-	6	3	54,870
STM	1010	18	6	-	4	2	95,870
Total:	6115					Total:	653,780

Assume 133 single-family units and 27 apartments in 3 buildings;
Total: 160 units.

House connections, 25 feet long at $1,650 each, 151 required;
Total cost: $249,150.

Unit cost for "utiliducts": ($653,780 + 249,150)/160 = $5,645
plus 20% = $6,800 per unit

Average cost of "utiliducts" = $106.91 per foot

UNIT COST - "UTILIDUCT" WITH PRESSURE SEWERS
Alternative (3)

Line	Length ft.	Outer Pipe in.	Pressure Sewer in.	Sewer Forcemain in.	Water Supply in.	Hot Water in.	Cost $
AB	500	21	4	6	6	4	47,580
BCD	450	21	4	6	6	3	43,490
DE	590	21	3	6	6	3	51,660
EFG	230	21	2	6	6	3	22,150
FHI	475	12	2	-	4	2	25,080
IJ	260	15	3	-	4	2	16,740
DJ	285	18	4	-	6	3	18,490
JKM	675	12	2	-	4	2	40,860
MNP	710	12	2	-	4	2	39,160
PR	430	15	3	-	4	2	25,520
RS	180	15	3	-	6	3	12,600
SB	320	18	4	-	6	3	20,760
STU	625	15	3	-	4	2	38,900
UM	385	12	2	-	4	2	17,650
Total:	6115					Total:	420,640

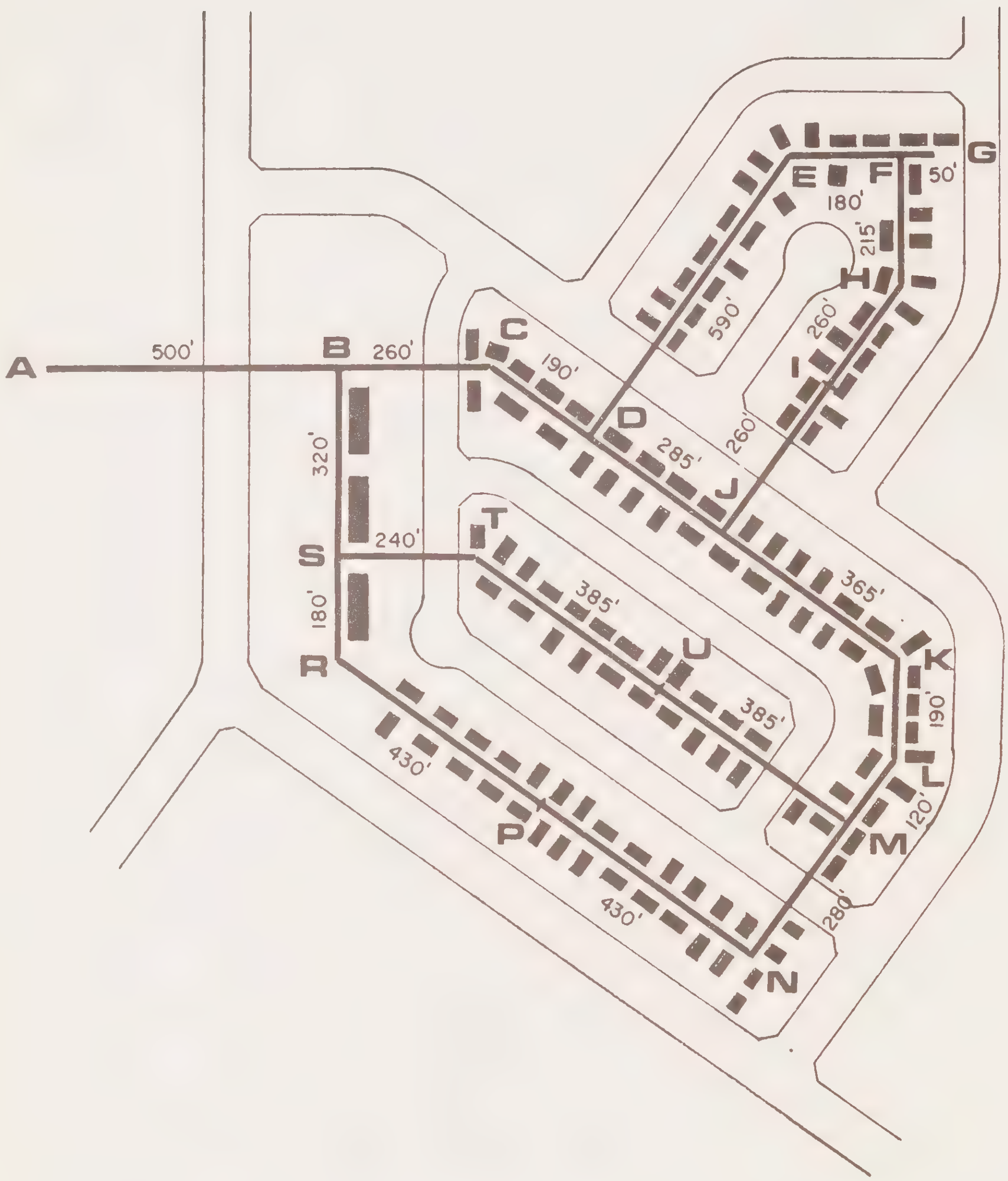
Assume 133 single-family units and 27 apartments in 3 buildings;
Total: 160 units.

House connections, 25 feet at $1,525 each, 151 required;
Total cost: $230,275.

Grinder Pumps, 151 at $2,500; Total cost: $377,500.

Unit cost: (420,640 + 230,275 = 377,500)/160 + 20% = $7,700 per unit.

Average cost of "utiliducts" = $68.79 per foot.



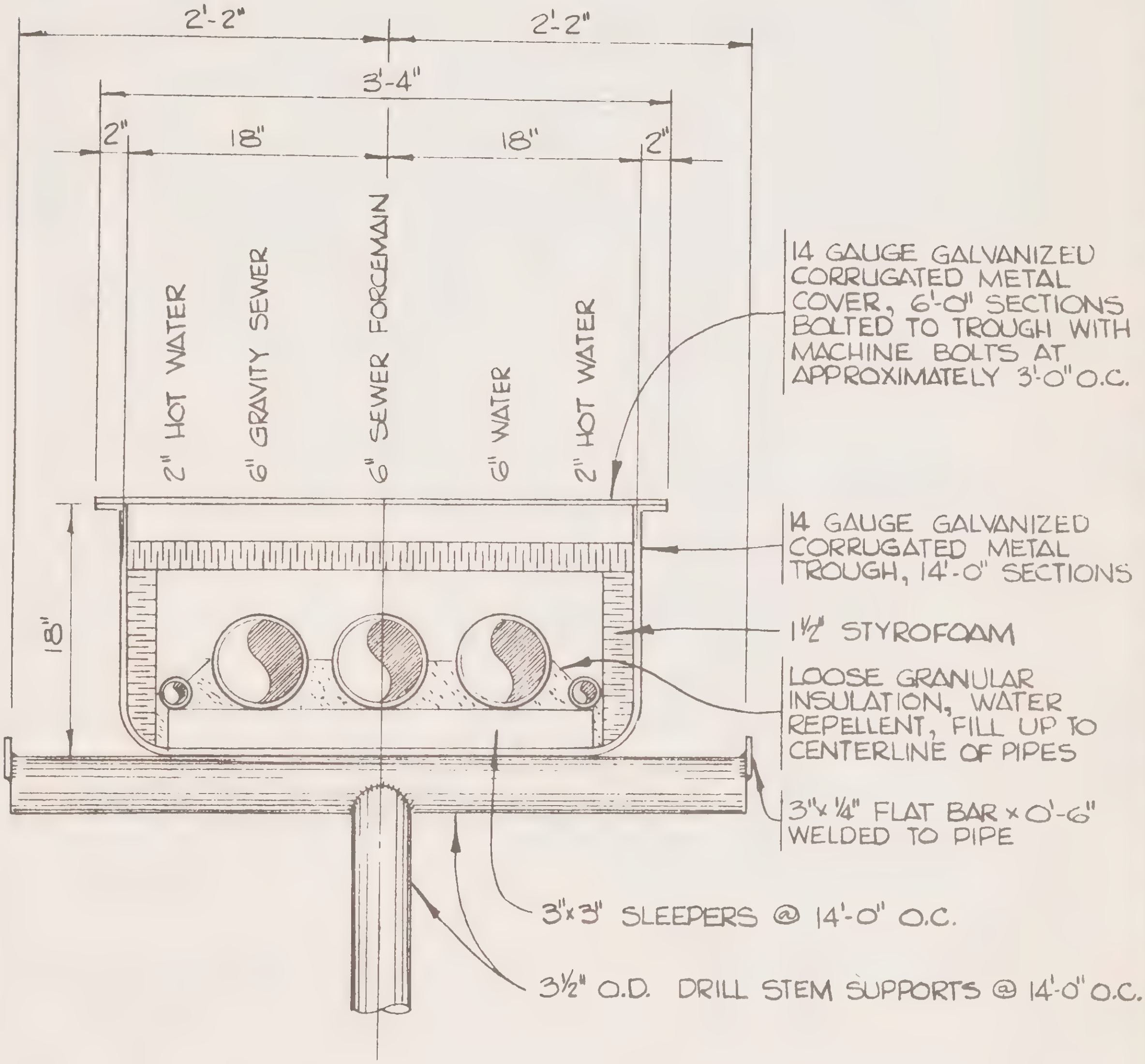
UTILIDOR LAYOUT - TYPICAL SUBDIVISION

W. J. FRANCL & ASSOCIATES

CONSULTING ENGINEERING LTD.

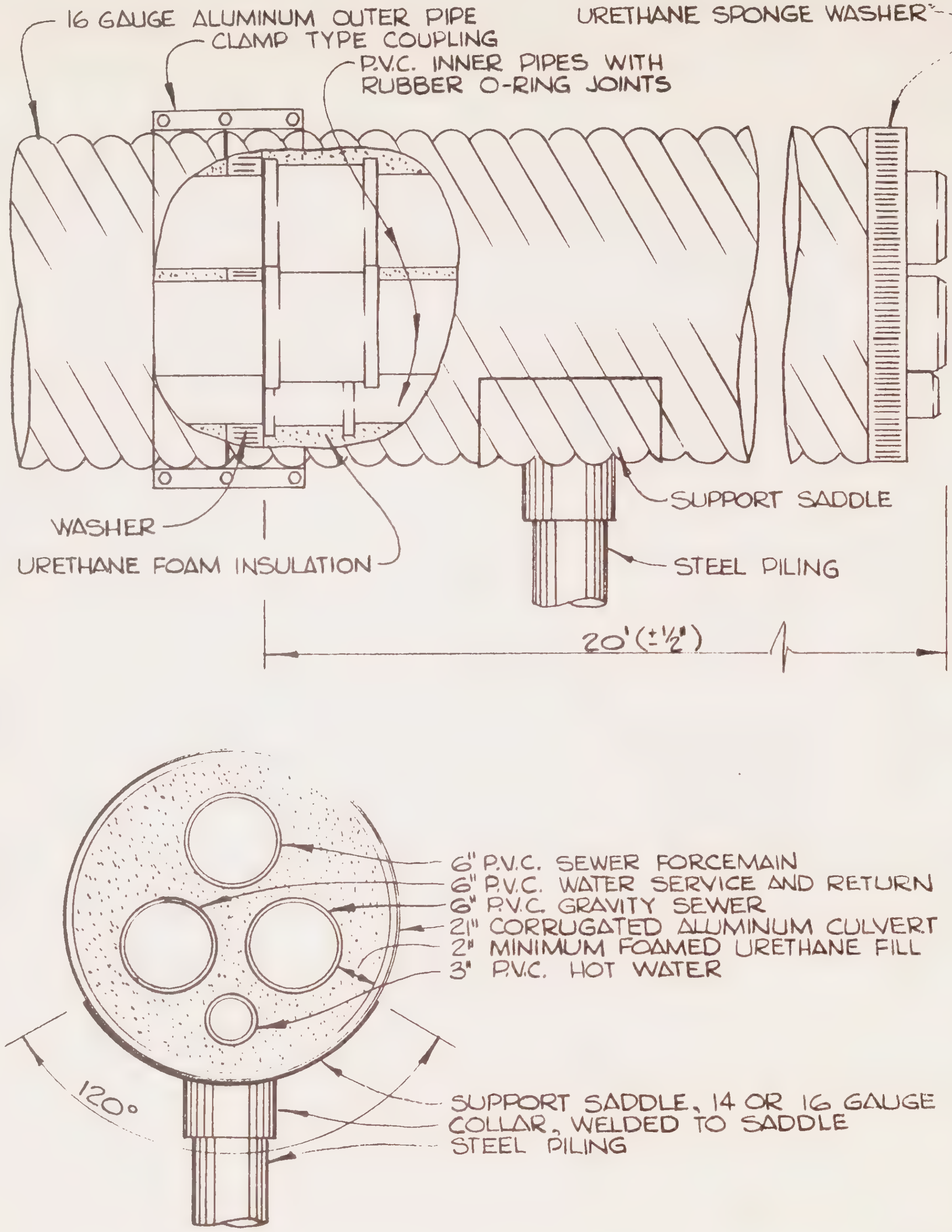
NORMAN WELLS N.W.T.

Approved By:	Drawn By:	Date:	Scale:	Sheet No.: E - I



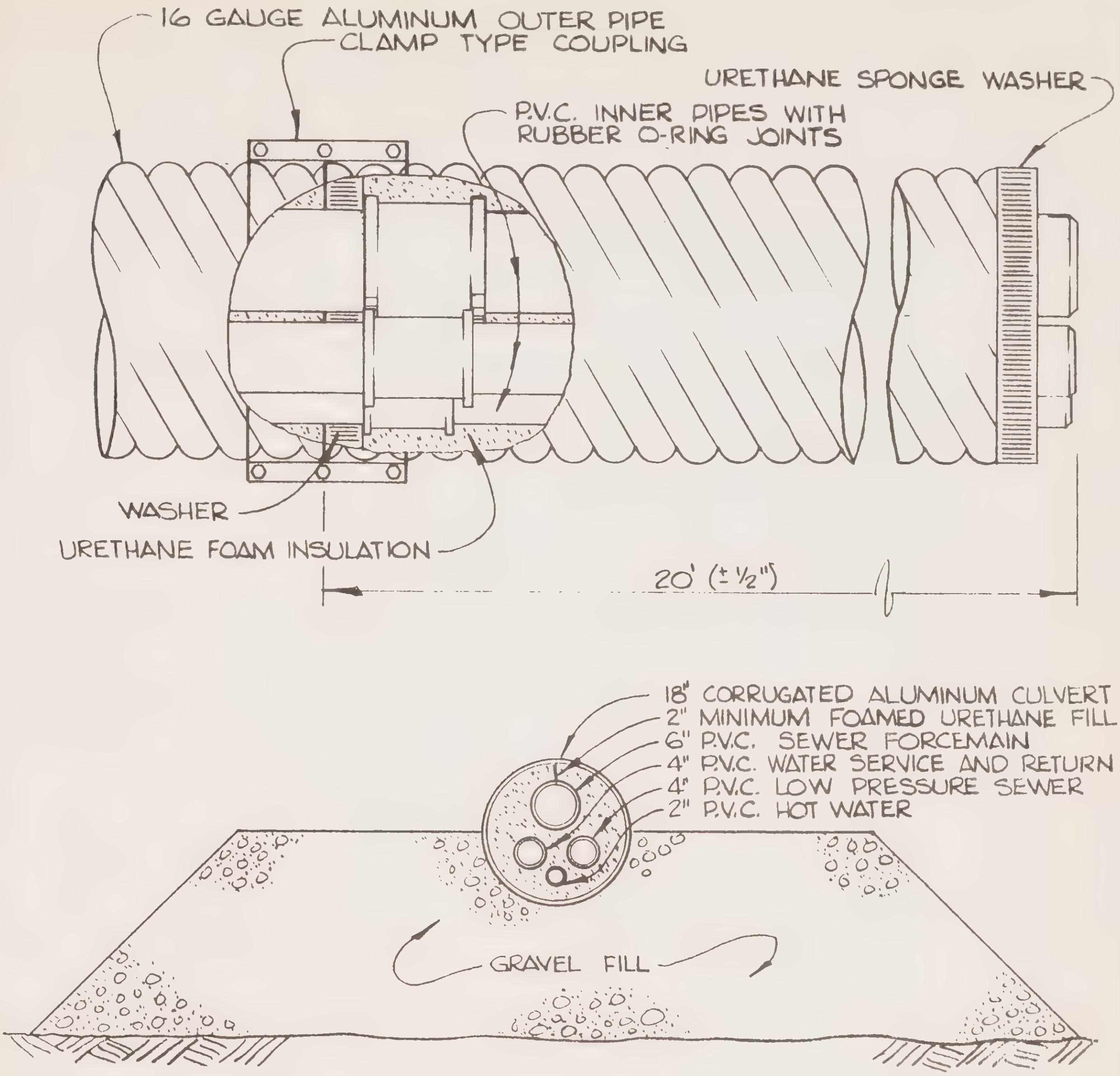
TYPICAL UTILIDOR – GRAVITY SEWERS

W. J. FRANCL & ASSOCIATES CONSULTING ENGINEERING LTD.	NORMAN WELLS N.W.T.			
Approved By:	Drawn By:	Date:	Scale:	Sheet No.: E-2



TYPICAL "UTILIDUCT" – GRAVITY SEWERS

W. J. FRANCL & ASSOCIATES CONSULTING ENGINEERING LTD.	NORMAN WELLS N.W.T.			
Approved By:	Drawn By:	Date:	Scale:	Sheet No.: E-3



TYPICAL "UTILIDUCT" — PRESSURE SEWERS

W. J. FRANCL & ASSOCIATES CONSULTING ENGINEERING LTD.	NORMAN WELLS N.W.T.

Approved By:	Drawn By:	Date:	Scale:	Sheet No.: E - 4

APPENDIX "F"

OFFICE AIRPHOTO STUDY

J.D. MOLLARD & ASSOCIATES LTD.

REPORT ON

OFFICE AIRPHOTO STUDY FOR

NEW NORMAN WELLS TOWNSITE

INTRODUCTION

This study deals with the interpretation of terrain conditions in vicinity of Norman Wells with the objective of locating a new townsite for that settlement. The site should be roughly 400 acres in area and should accommodate a population of 4000.

Main considerations include the type of near-surface soil and rock materials and the depth to bedrock as they relate to foundation quality (particularly differential ground heave and ground settlement), topographic and surface drainage conditions within five miles of the Norman Wells airstrip, fluvial and thermal erosion, and proximity to a suitable municipal water supply. Other considerations taken into account are access, sewage disposal, natural vegetative cover, fire history, possible adverse climatic and microclimatic effects, flooding hazard, and proximity to existing or proposed transportation routes including the proposed Mackenzie Highway and the Mackenzie River.

Reference materials used in this study include bedrock and surficial geology maps, panchromatic and color infrared (false color) aerial photographs, and mosaics and borehole logs along the proposed Mackenzie Highway.

Surficial mineral-soil materials in the immediate Norman Wells area consist mostly of stratified clayey silt with lesser silty clay and silty fine sand that were deposited in a former glacial lake. It is believed that the glacial lake stood at a maximum elevation of approximately 400 feet above sea level in vicinity of Norman Wells. The fine-grained glacial-lake sediments are overlain by peat in depressions and are underlain by glacial till, which is more or less continuous over bedrock on the sloping valley side up to approximately elevation 750 feet. Total thickness of glacial drift materials is variable; but the thickness is expected to range from about 20 feet at Norman Wells to zero where bedrock outcrops are common above elevation 750 feet.

Till situated above the inferred maximum glacial-lake elevation of about 450 feet is covered by a layer of predominantly silty slopewash sediment a few feet thick. In fact, in the field it may be difficult to make a clear distinction between glacial-lake (lacustrine) and slopewash sediments in vicinity of elevation 400 feet, where these two different types of surficial materials are expected to occur.

From the inspection of available borehole logs, it is expected that both the silty lacustrine and the silty slopewash materials will have a high, as well as random, occurrence of excess ice -- especially in

the zone from 3 to 5 feet below ground surface. The glacial till is expected to be considerably denser and to contain substantially less excess ice than the lacustrine and slopewash deposits, particularly below a depth level of about 5 feet in till (which is assumed to be the upper weathered layer that is subject to repeated freeze-thaw cycles, including the active layer).

A long and narrow trough-shaped depression between the present townsite and the hillslope is characterized by surface peat that is several feet thick and by thermokarst topography resulting from melting of ground ice.

A narrow, discontinuous sandy fluvial terrace lies just above the right bank of the Mackenzie River. It is best developed between DOT Lake and the Mackenzie River, and has been considered as a potential new townsite area (Area 2). It is anticipated that excess ice contents will be lower (or possibly non-existent) in the sandy terrace. As a result, differential thermal subsidence should be less of a problem than it is in the nearby fine-grained lacustrine and slopewash materials.

BEDROCK GEOLOGY AND MATERIALS -- GENERAL

Study of drillhole logs indicates that the bedrock consists of shale in the immediate Norman Wells area. It is expected that the shale encountered in drillholes is the Upper Devonian Imperial Formation, which contains both shale and sandstone members. Above elevation 750 feet approximately, the Upper Devonian Fort Creek Formation (re-named the Middle Devonian Kee Scarp Formation in 1963) occurs and consists of bituminous shale with coral reef and other limestone members (e.g. at the present rock quarry site). Shale beneath the glacial drift or where exposed at ground surface in vicinity of Norman Wells is expected to be a relatively poor material in foundations, having a high excess ice content in the upper weathered layer of 3 to 5 feet thickness.

PERMAFROST

The mean annual air temperature at Norman Wells is 21°F. The ground temperature at a depth of 50 to 100 feet is 26° to 29°F, and the permafrost is some 150 to 200 feet thick. The active layer thickness under stable vegetation varies from about 2 to 5 feet in well-drained and imperfectly drained fine-grained materials, but it is over 5 feet in sandy deposits. The active layer is about 2 feet or even less thick in dry moss or lichen insulated peatlands. However, the ground is unfrozen in peatlands where there is standing water, as in poorly drained depressions.

Alternate Townsite Area "A"

Topographically, this area would be suitable for a new townsite. It is situated near Bosworth Creek, which could provide a suitable municipal water supply. But the southwest corner of the area is situated in a wet depression. It is expected that peat, possibly up to 5 feet deep, will be encountered in this poorly drained area. High excess ice contents locally, which could result in excessive ground settlement upon thawing, are also expected to occur in the southwest corner of Area "A" (see Fig. 1). The remainder of Area "A" is expected to be underlain by fine-grained soils possessing excess ice in the upper 3 to 5 feet below ground surface. However, this situation will likely be true for most of the Norman Wells area. One of the things that particularly concerns us is surface drainage and the possibility of fluvial and thermal erosion on long uniform slopes after the vegetation has been removed during the period of townsite development. Streets and ditches of any kind should parallel the contour wherever this is possible. Tree vegetation is sparse and stunted and offers very little shelter.

Alternate Townsite Area "B"

Area "B" is located on an approximate 5% slope, which may be steep enough to promote fluvial and thermal erosion problems as well as thermal subsidence following disturbance of the vegetation, particularly

if townsite development is not very closely and carefully controlled. Excess ice in the upper 10 feet below ground surface is also expected to occur in this area. Considerably greater distance to a municipal water supply and resulting terrain disturbance and associated problems must also be considered.

Alternate Industrial Area "C"

Part of this area is low-lying, is wet, and is covered with up to 5 feet of peat. The area also contains thermokarst features, indicative of randomly-occurring high excess ice contents (see Fig. 1). Construction in both the southerly and northerly portions of the area will likely create difficult foundation and drainage problems -- similar to those encountered at the existing Norman Wells Townsite.

Alternate Industrial Area "D"

Similar to Area "B"," above. Major disadvantages include the moderate slope, poor foundation materials, sparse vegetative cover, and susceptibility to erosion.

Alternate Industrial Area "E"

Most of this area is expected to be similar to the existing townsite so far as foundation conditions are concerned. A local exception is the more densely treed southerly terrace portion, an area of which is occupied by Pan Cana and Tower Trucking. Soils in this southerly portion are expected to be sandier in texture and to contain lower ice contents, and thus offer better foundation conditions. It is doubtful

whether a municipal water supply for this area could be obtained from a well installed in unfrozen alluvium in the nearby Mackenzie River. However, if sufficient thickness of permeable alluvial sand could be found in the nearby Mackenzie River and a proper well constructed, its design would have to consider the dangers of flooding and ice jams, both common occurrences at Norman Wells.

Alternate Townsite Area "F"

Conditions at this site are similar to those at Area "A", described above.

Alternate Townsite Area "G"

Terrain conditions in this area are about the same as those at most of the other areas considered here. The cross slope is approximately 2.5%, which should be satisfactory so far as surface drainage is concerned -- that is, the slope should prevent ponding of surface runoff waters and yet be gentle enough to avoid high channel velocities. Also, see our recommended Area 3.

Alternate Townsite Area "H"

Similar to Areas "B" and "D" except that this area has a slope of approximately 7.5%, which is steeper than either Areas "B" or "D." As a result, the area would likely present more serious surface drainage and erosion problems.

Existing Norman Wells Townsite

Large-scale future development at the existing townsite is restricted by the Mackenzie River, by the airstrip, the wet linear depression (marked "W" on Figure 1), and by Bosworth Creek. The area is fairly flat; and unless adequate drainage were provided, ponded waters could cause melting of ground ice and thermal subsidence. In fact, thermal subsidence appears to have occurred in several areas already (see Fig. 1). Foundation problems at future building sites are expected to be similar to those experienced to date at Norman Wells.

POSSIBLE ACCESS ROADS

The best location of possible access roads will of course depend upon the townsite that is finally chosen. Generally, all areas marked "W" on Figure 1 are wet and peat-covered, and should be avoided wherever possible. Two prospective easterly access road locations are shown. They are located to either entirely or partly follow existing roads. The access road location shown farther to the west parallels Bosworth Creek. However, it might be shifted slightly closer to Bosworth Creek in order to provide somewhat better terrain conditions. It should not be located so close to the valley banks of Bosworth Creek to induce thaw and thus bank and roadbed instability.

OTHER RECOMMENDED TOWNSITE AREAS (see FIGURE 1)

If the Norman Wells townsite is relocated, extensive field reconnaissance, including selective test drilling, will be required to confirm the most suitable townsite location. In our opinion, there do not appear to be any what we would call "good" townsites in the area. The main problem concerns poor foundation materials containing high excess ice content in clayey silt lacustrine and slopewash deposits and in the upper weathered layer of till and shale bedrock.

An ideal location would be a relatively flat area situated on deep clean granular soils, such as occur in certain large glacial outwash plains and large fluvial terraces. Similarly, a large area underlain by hard, essentially flat-lying sedimentary bedrock -- such as limestone or sandstone -- would also be acceptable. But the surface should be flat to gently sloping. Generally, clay shales, siltstones, and mudstones contain excessive ice contents in the near-surface and should be avoided if possible. The hoped-for conditions mentioned above do not occur in the Norman Wells area -- at least not within the proposed study-area and in the neighboring area that was examined in airphotos.

As a result of this office airphoto study, we have identified four possible alternate townsite areas. Some of these include parts of areas that you have suggested as prospective townsite locations (see the 4 coarsely cross-hatched areas on Figure 1).

Area 1

Although the outlined area may not be large enough to accommodate the proposed future development, we believe this area should receive careful field checking for a possible townsite relocation. Detailed inspection on the ground may be all that would be required to determine its suitability as a townsite.

Unfortunately, the area is very long and very narrow, and is situated on a ridge, with bedrock near ground surface. It is likely that a veneer of only 2 or 3 feet of glacial drift overlies hard bedrock. Sides of the ridge drop off precipitously to the north and appear to slope steeply to the south. The ridge supports a fairly dense tree cover; and it is because of the trees that it is not possible to determine the precise width nor visualize the character of microrelief features from the study of 1 inch = 4200 foot aerial photographs.

A municipal water supply could likely be obtained from nearby Hodgeson Lake, which appears to contain deep water near its shore. Storage of municipal water on higher terrain at the end of the ridge would supply pressure to a Town water-distribution system.

Depending on environmental regulations, properly treated sewage could be discharged down Bosworth Creek and thence into the Mackenzie River.

The area is situated near the proposed Mackenzie Highway, and cost of access road construction would be minimal.

The view from this location would be excellent, with the Mackenzie River in the distance to the southwest and mountains to the northeast.

Most important of all, foundations could be very favorable. If it is felt that shape of the elongate area were not too objectionable, the area might be examined closely on the ground.

Area 2

This area is situated on what appears to be a sandy terrace along the Mackenzie River. Test drilling would be required to determine the depth of sandy soil materials and also their ice content.

This area also has a poor shape (long and narrow), is limited in size, and its expansion is restricted by the river and nearby lakes. If the area were to be considered seriously for possible residential purposes, the float-plane dock on DOT Lake would have to be relocated.

It is unlikely that a water supply could be obtained from a well installed in unfrozen alluvium along the Mackenzie River. In any event, any such well would have to be located above flood and ice-jam levels. It is likely the river bed at the shore line is cut into till or into bedrock; and so a deep, clean, coarse aquifer at the river's edge is an unlikely possibility.

A portion of this area is located in your Alternate Industrial Area "E". Proximity of the area to the Mackenzie River is desirable for an industrial site because of nearby river-barge service.

Area 3

This area includes portions of your possible Townsites "A" and "G". The slope on this area is approximately 2.5%, which is sufficient to prevent surface runoff water from ponding and yet not steep enough to instigate excessive erosion.

It appears that a water supply might be obtained from Bosworth Creek. Treated sewage could be returned to Bosworth Creek well downstream from the water supply intake.

Test drilling in this area might locate an area where the lacustrine clayey silt overlying glacial till is shallow, inasmuch as this area is located near the upper margin of the former glacial lake (at 400 feet) and is below the elevation of thicker ice-rich slope-wash sediments. Access roads to the area could be combined with those to the airstrip.

Area 4

Hopefully this area may contain somewhat lower excess ice contents in the upper 10 or so feet. But this would have to be checked in detail in the field. No obvious nearby suitable water source appears to exist. Moreover, the proposed Mackenzie Valley gas pipeline crosses the site-area.

If it is considered desirable to keep the townsite and industrial areas separate, the possibility of locating the townsite in Area 1 and the industrial site in Area 2 might be considered. However, these two

areas might be too far apart for convenience (approximately 2.8 miles). Such an arrangement would place the industrial area near airstrip and river-barge service. It would also separate the residential area from the above areas.

Areas 3 and 4 are large enough to accommodate combined residential and industrial areas.

SUMMARY

In summary, there are no ideal townsites in vicinity of Norman Wells, but some areas of 400 acres or more offer slightly better qualities than others. All except Area 1 present building foundation concerns and some potential for erosion.

We consider the best combination from a topographic and drainage standpoint would be residential development in Area 4 and industrial development in Area 2 with water obtained either from Hodgeson Lake or the Mackenzie River. However, the proposed pipeline route passing through Area 4 must receive consideration. A second choice is Area 1 for residential and Area 2 for industrial but these two areas are probably too far apart for convenience.

Access to these areas may be by any of the roads shown on Figure 1.

Unless your proposed cost analysis demonstrates that one of the alternate sites possesses a decided advantage over existing Norman Wells Townsite, I think one is almost obligated to carry out some sort of selective visual field reconnaissance, followed by a certain amount of predetermined testhole drilling. The test drilling should concern not only the quality of foundation conditions at the possible sites of large buildings but should also test, in a preliminary way, for a suitable groundwater supply.

The resulting field information, coupled with the fact that the present site offers very little space for future expansion, may make your decision clear cut. The decision might also be affected by whether or not the proposed Mackenzie Valley gas line goes ahead, which in turn would determine whether or not the Mackenzie Highway were constructed as far south as Norman Wells.

If none of the above alternates are satisfactory, the nearest most-favorable-looking site on the east side of the Mackenzie River might be considered. This is the wooded area on the north side of Oscar Creek, some 20 miles northwest of Norman Wells. The best site is located at the base of the escarpment where the Oscar Creek cuts through the Norman Range.

APPENDIX "G"

SOILS INVESTIGATION - EXISTING TOWNSITE

ELMER W. BROOKER & ASSOCIATES LTD.

consulting civil engineers

G.R.Gilchrist, MSc. P.Eng.
vice president

November 28, 1972

W. J. Francl & Associates Consulting Engineering Ltd.
204 11445 - 124 Street
Edmonton, Alberta

Attention: Mr. Jack Paterson, P. Eng.

Gentlemen:

Subject: Norman Wells Subdivision - Soil Borings

Twenty boreholes were dry augered to a maximum depth of 20 feet below grade at the locations indicated on the attached site plan, Drawing No. A-1. Detailed borehole logs are enclosed herein.

It is our understanding that an evaluation of subsurface conditions is not required at this time. Hence, we enclosed the data obtained for your review. Should you have any questions concerning the information presented, please contact our office, at your convenience.

Respectfully Submitted,

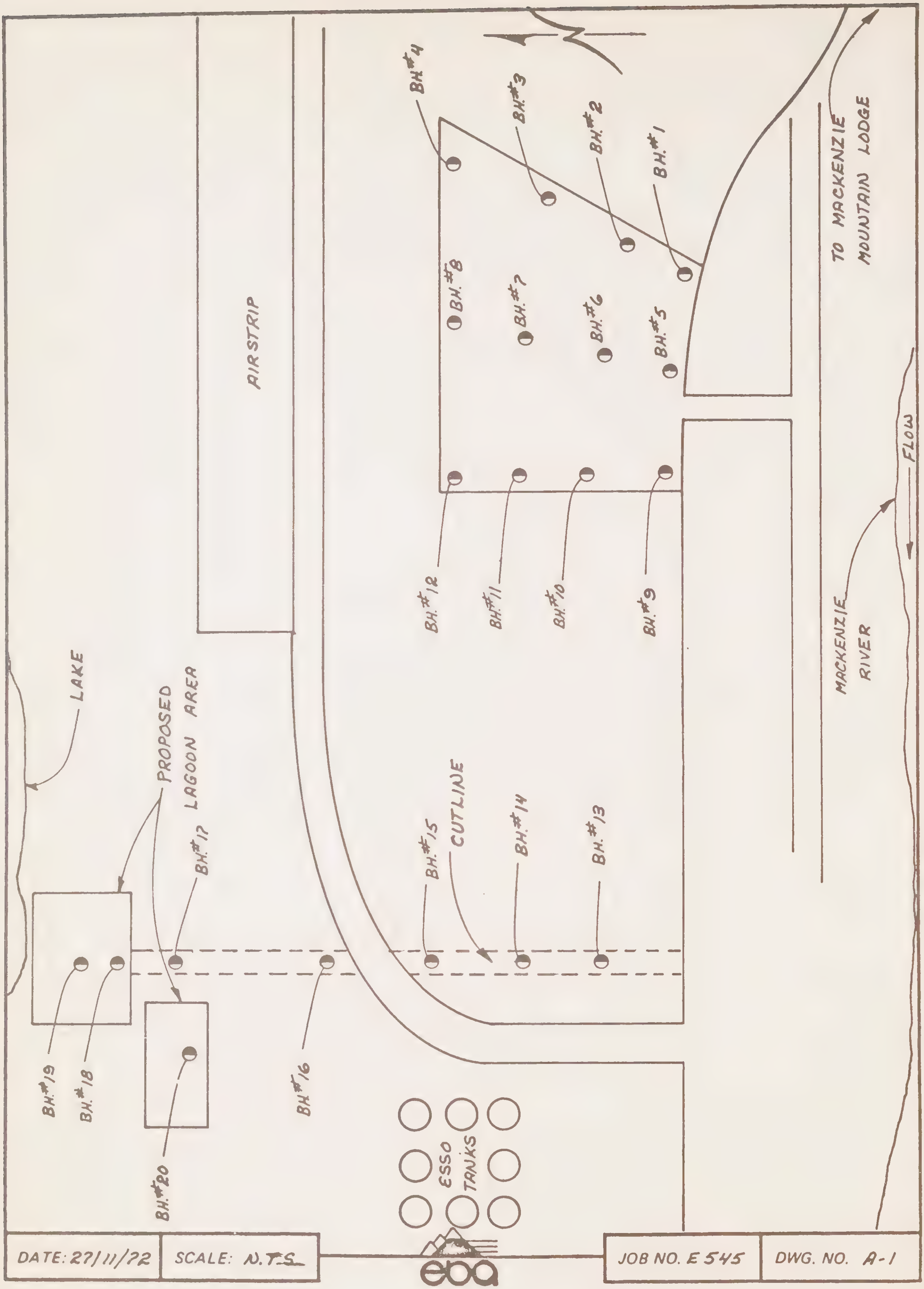
ELMER W. BROOKER & ASSOCIATES LTD.

Garry R. Gilchrist

Garry R. Gilchrist, P. Eng.

GRG:sjw

Enclosures Site Plan
Borehole Logs



BH.#1
BH.#2
BH.#3
BH.#4
BH.#5
BH.#6
BH.#7
BH.#8
BH.#9
BH.#10
BH.#11
BH.#12
BH.#13
BH.#14
BH.#15
BH.#16
BH.#17
BH.#18
BH.#19
BH.#20
TO MACKENZIE MOUNTAIN LODGE
FLOW
MACKENZIE RIVER
AIRSTRIP
LAKE
PROPOSED LAGOON AREA
CUTLINE
ESSO TANKS
DATE: 27/11/72
SCALE: N.T.S.
JOB NO. E 545
DWG. NO. A-1

SYMBOLS & TERMS USED ON BORING LOGS

I. Soil Description

Major Divisions	Subdivisions	Field Identification
COARSE-GRAINED SOILS	COBBLES AND BOULDERS	Larger than 3 inches diameter - cobbles 3 to 8 inches - boulders greater than 8 inches
	GRAVEL	Smaller than 3 inches but larger than No. 10 Sieve (2 mm.)
	SAND	Smaller than No. 10 sieve but larger than .06 mm. Smaller particles are not visible to the naked eye.
FINE-GRAINED SOILS	SILT	Exhibits dilatancy (reacts to the shaking test). Powders easily when dry, only slight dry strength. Gritty to the teeth. Dries rapidly. No shine imparted when moist and stroked with knife blade.
	CLAY	Not dilatant. Possesses appreciable dry strength. When moist, sticks to fingers and does not wash off readily. Not gritty to the teeth. When moist a shiny surface is imparted when stroked with a knife blade.
ORGANIC SOILS	PARTLY ORGANIC - organic clay - organic silt etc.	Depending on amount of organic material, these soils usually have some of the characteristics of their inorganic counterparts: usually highly compressible (spongy) usually have characteristic odour.
	ORGANIC MATERIAL - peat	Fibrous structure - usually brown or black when moist. Spongy. Usually has characteristic odour.

(After NRC TM #37 with modifications for MIT Grain Size Scale.)

II. Ice Description

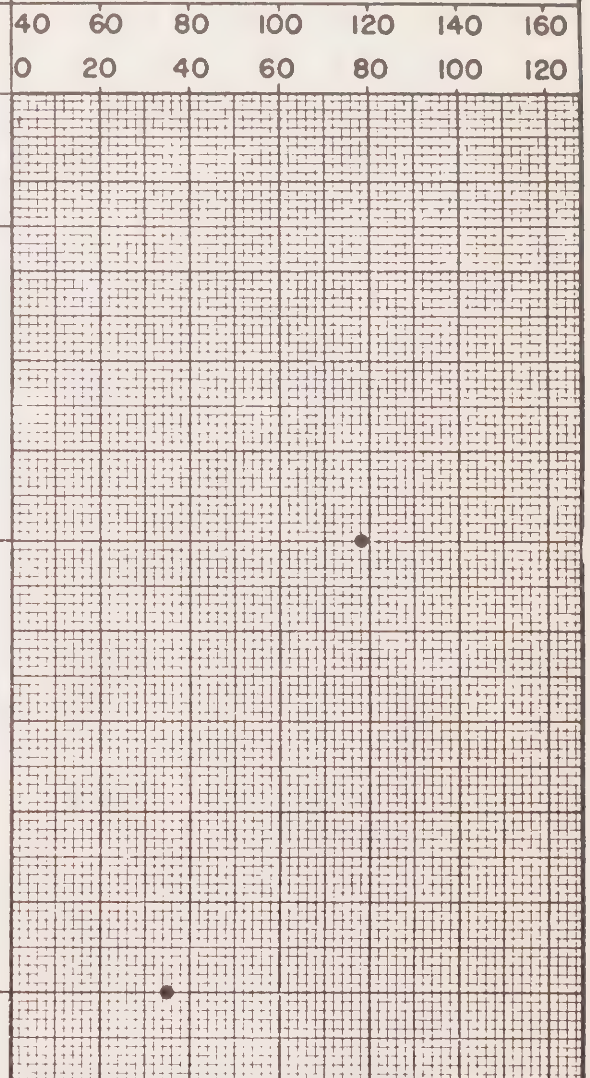
Non Visible Ice	Nf Nbn Nbe	Poorly bonded Well bonded Excess Ice
Visible Ice Less than 1 inch thick	Vx Vc Vr Vs	Individual ice crystals or inclusions Ice coatings or particles Random or irregularly oriented ice formations Stratified or distinctly oriented ice formations
Visible Ice Greater Than 1 inch thick	ICE + ICE	Ice with soil inclusions Ice without soil inclusions

(After NRC TM #79)

E.W.Brooker & Associates Ltd.

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
MUSKEG - frozen		0	
		1	
- unfrozen		2	
		3	
		4	
SILTY CLAY - grey siltier with depth frozen		5	Vx ≈ 20%
		6	
		7	
		8	
		9	
		10	

DRY DENSITY p.c.f. X
WATER CONTENT % ●



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PROJECT
Norman Wells Subdivision

E-545

DATE Nov. 10/72

LOGGED BY H.C.

ELEVATION N.A.

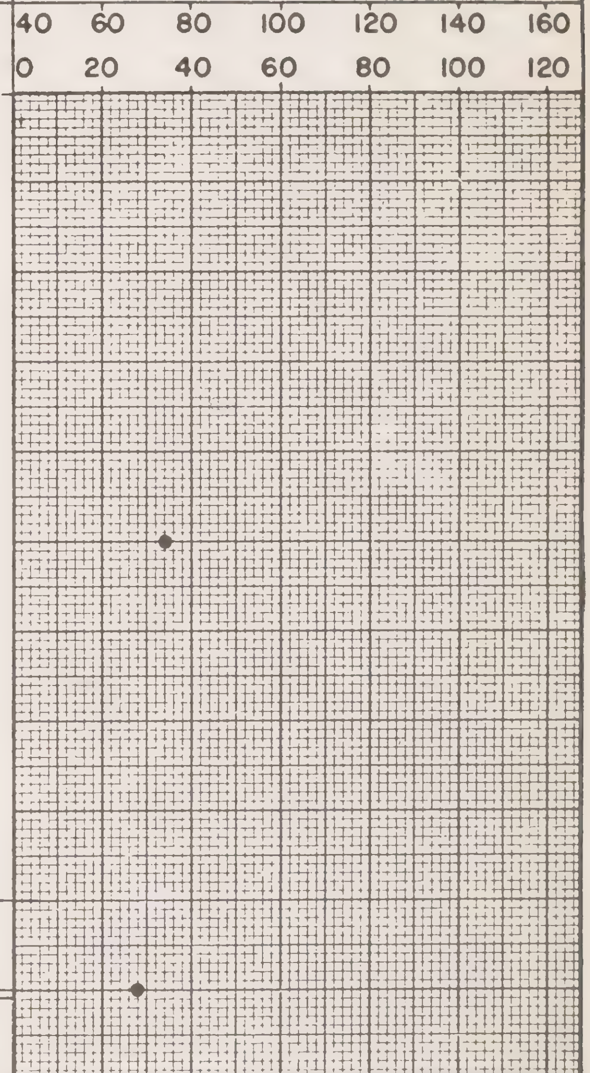
DEPTH 20'

HOLE NO. 1

SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
silty clay			Vx ≈ 20%
		11	
		12	
		13	
		14	
		15	
SILT - grey			
		16	
		17	
		18	
		19	
SHALE - sandy & silty grey			Nbn
		20	
END OF HOLE			

DRY DENSITY p.c.f. X
WATER CONTENT % ●



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 10/72

LOGGED BY H.C.

ELEVATION N.A.

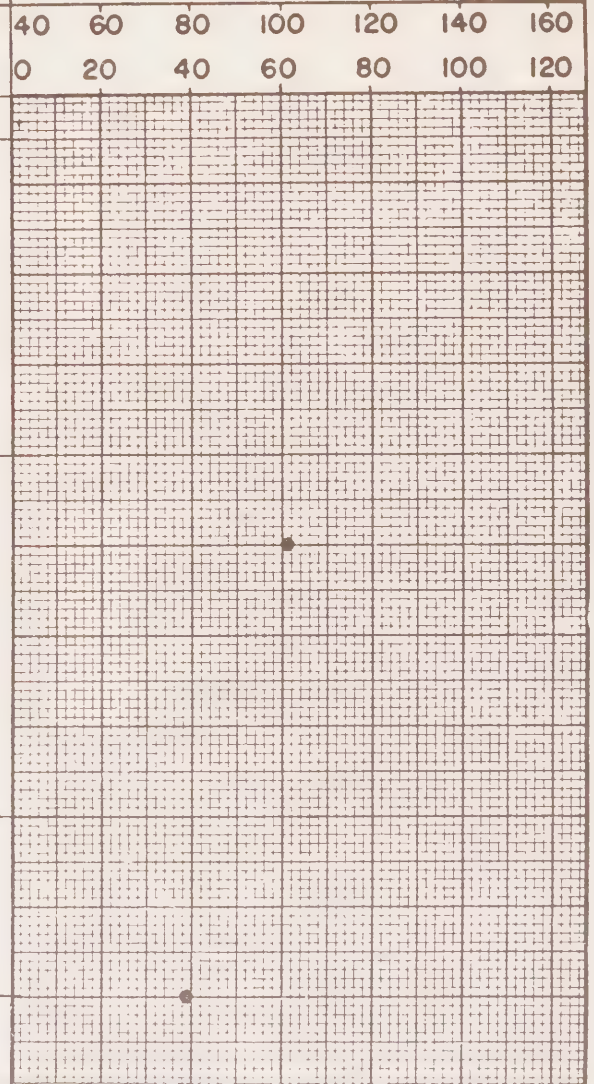
DEPTH 20'

HOLE NO. 1

SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		0	
MUSKEG - frozen			
- thawed saturated		1	
		2	
		3	
SILT - grey mottled rootlets frozen		4	Vx ≈ 40%
		5	
		6	
		7	
- silt grey frozen		8	Vx ≈ 30%
		9	
		10	

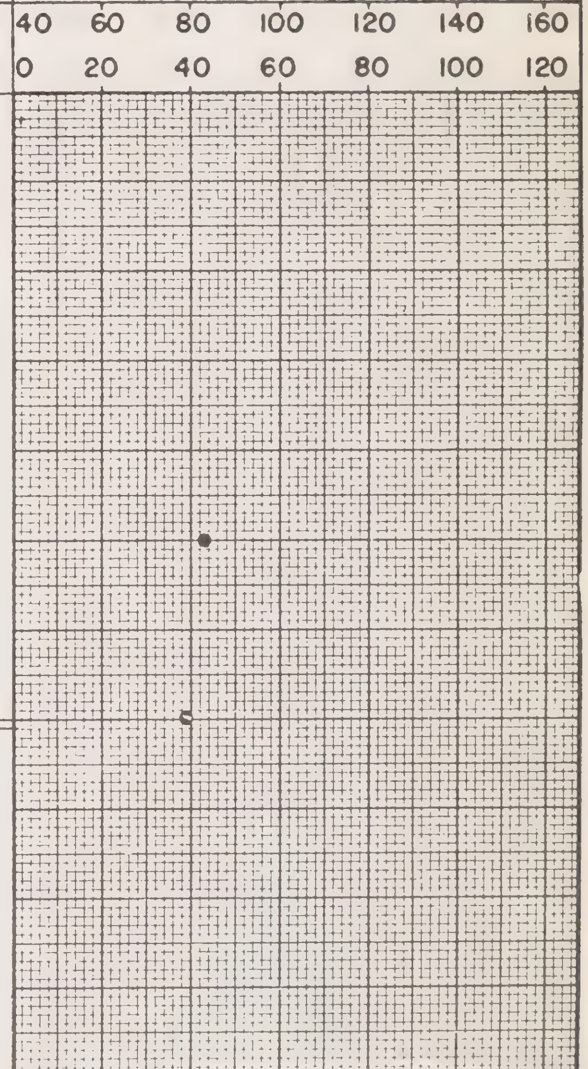
DRY DENSITY p.c.f. X
WATER CONTENT % ●



civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 17'	HOLE NO. 2 SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
SILT - continued			
		11	
		12	
		13	
		14	
		15	
		16	
- refusal on rock			
		17	
END OF HOLE			

DRY DENSITY p.c.f. X
WATER CONTENT % ●



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 9/72

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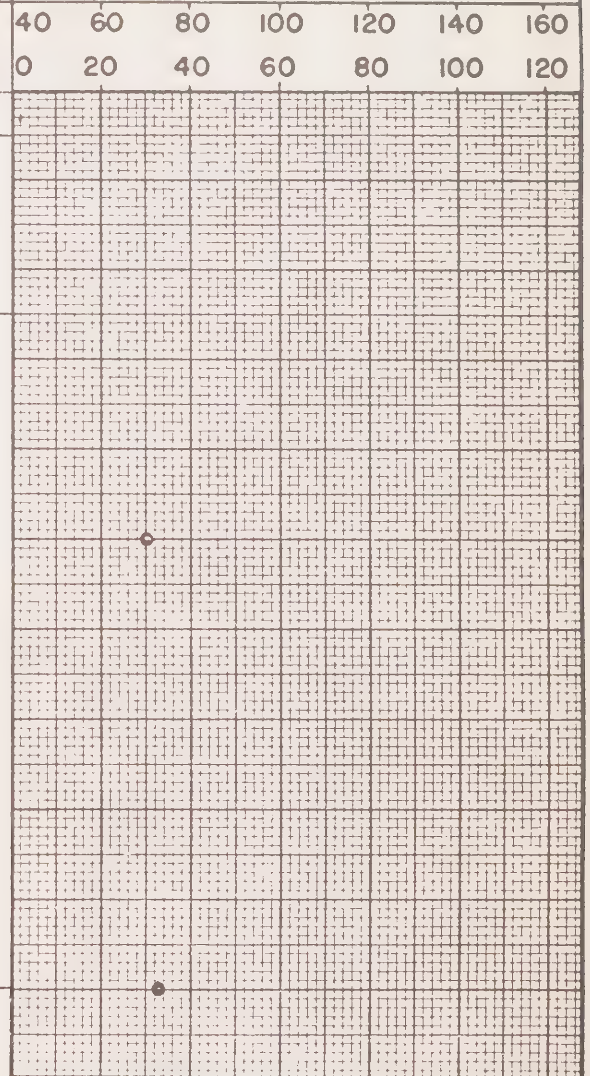
ELEVATION N.A.

DEPTH 17'

HOLE NO. 2

SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
MUSKEG - frozen		0		
- saturated thawed		1		
		2		
SILTY CLAY - grey frozen		3	Vx ≈ 50%	
		4		
		5		
		6		
		7		
		8		
		9		
		10		



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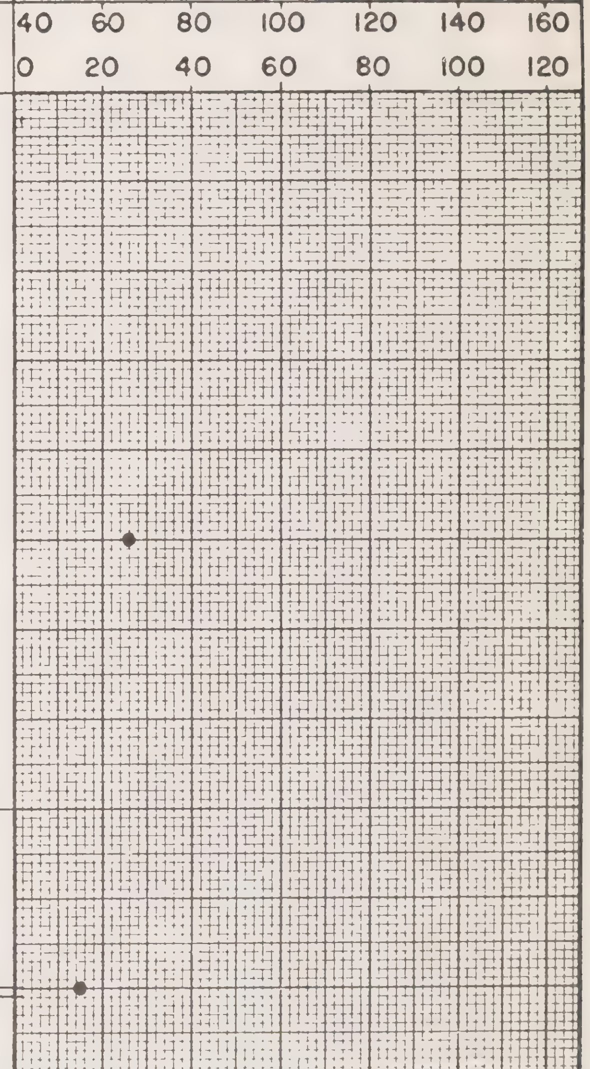
PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 3 SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
- silty clay		10 – 18	Vx ≈ 30%
SHALE - grey sandy & silty frozen		18 – 20	Nbn
END OF HOLE		20	

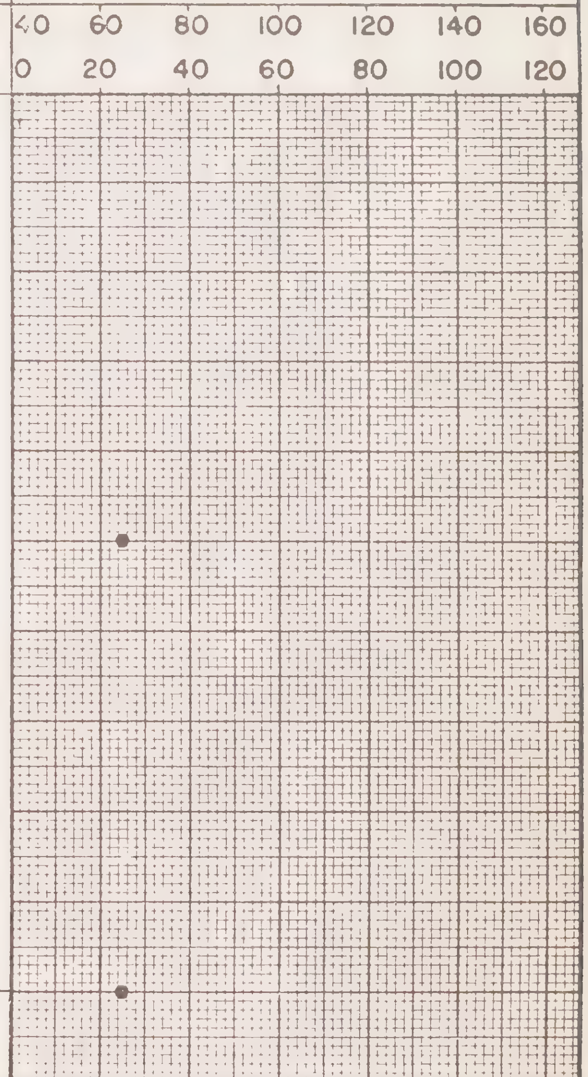
DRY DENSITY p.c.f. X
WATER CONTENT % ●



civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 3 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
SANDY SILT - saturated thin sand lenses brown thawed		0	
		1	
		2	
		3	
		4	
		5	
		6	
		7	
- rock		8	
		9	
		10	

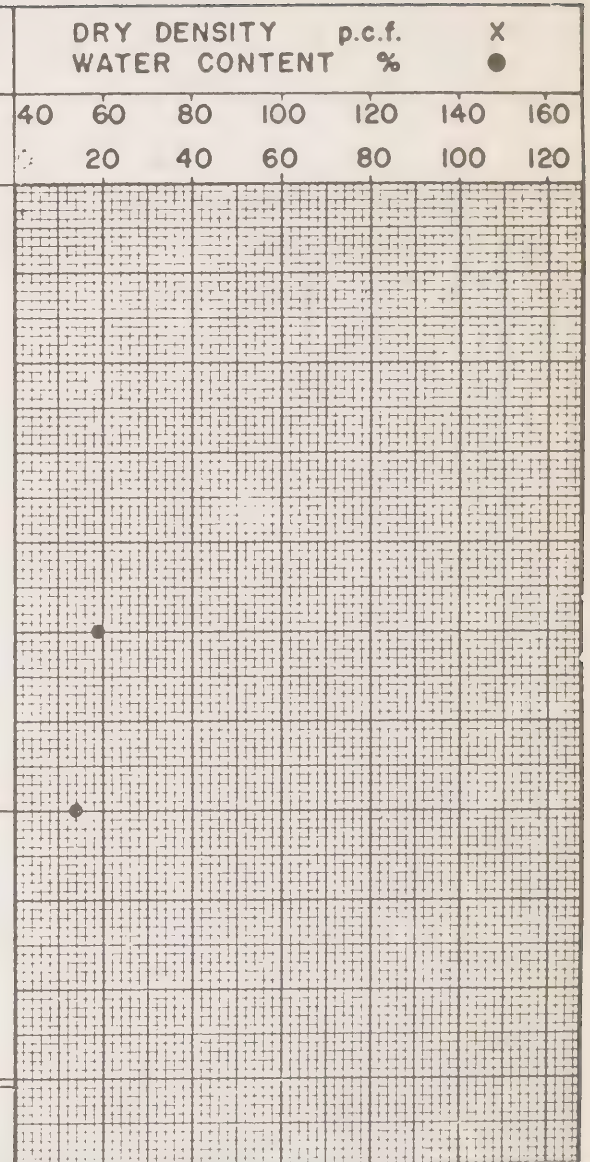
DRY DENSITY p.c.f. X
WATER CONTENT % ●



eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 4 SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
		11	
		12	
		13	
		14	
		15	
		16	
SHALE - sandy & silty grey thawed		17	
		18	
		19	
		20	

END OF HOLE
NOTE: (1) Hole sloughed to 5' @ 0 Hrs.



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PROJECT Norman Wells Subdivision
E-545

DATE Nov. 9/72
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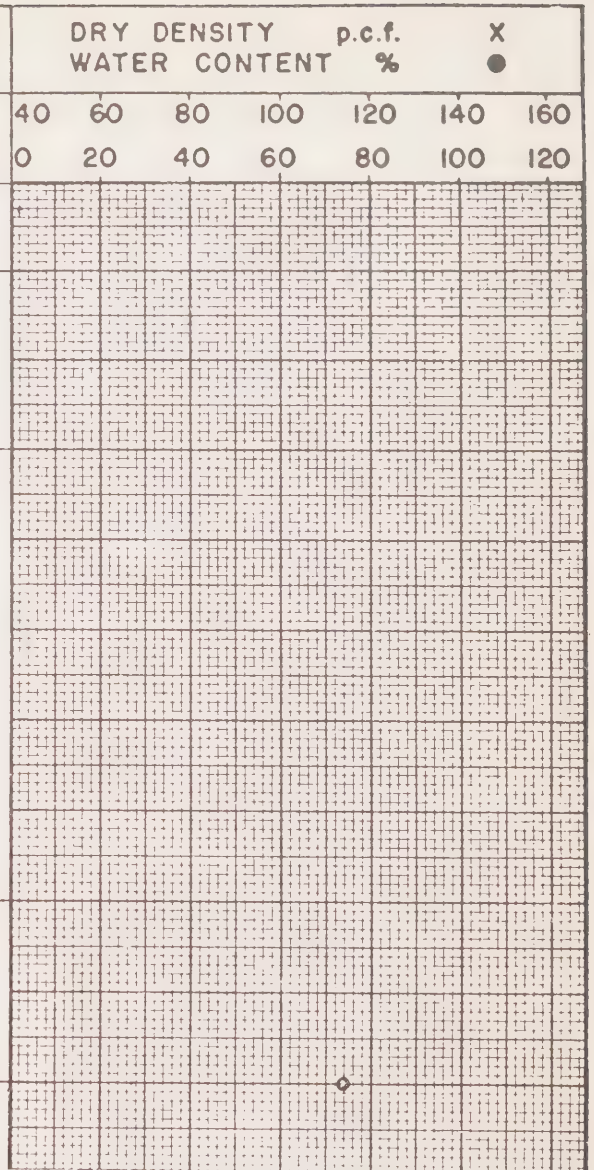
ELEVATION N.A.
DEPTH 20'

HOLE NO. 4
SHEET 2 of 2

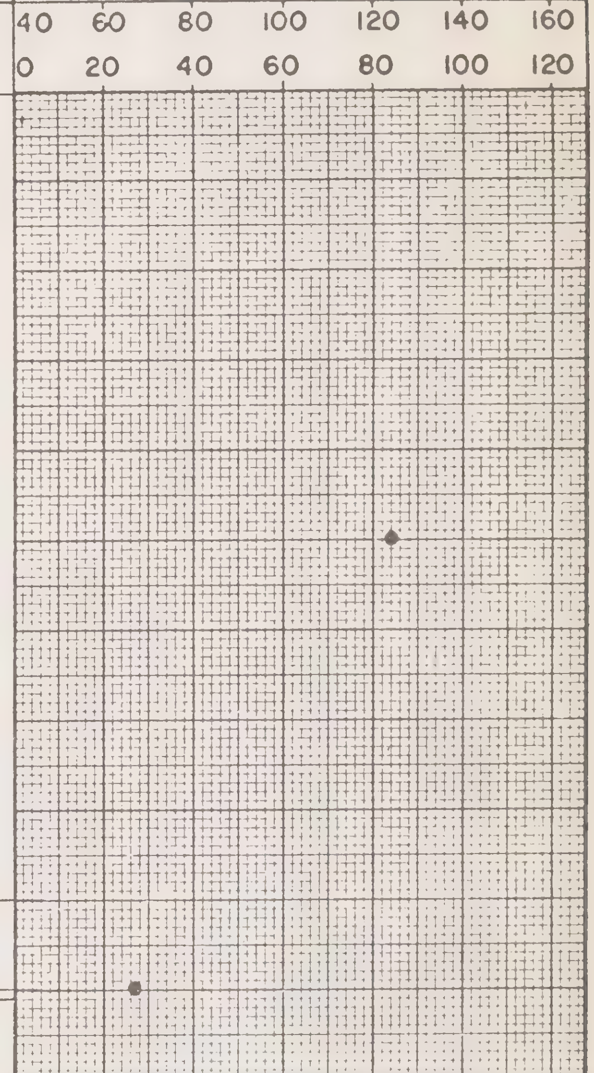
SOIL DESCRIPTION	SAMPLE TY .	DEPTH FT.	ICE DESCRIPTION (NRC)
		0	
MUSKEG - frozen to 1'			
- thawed saturated		1	
		2	
SILTY CLAY - mottled grey frozen		3	Vx ≈ 30%
		4	
		5	
		6	
		7	
- hard from 8' to 13'		8	Nbn
		9	
		10	



civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 5 SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
		11	
		12	
		13	
		14	
		15	
		16	
		17	
		18	
		19	
SHALE - sandy & silty grey, frozen			Nbn
		20	
END OF HOLE			

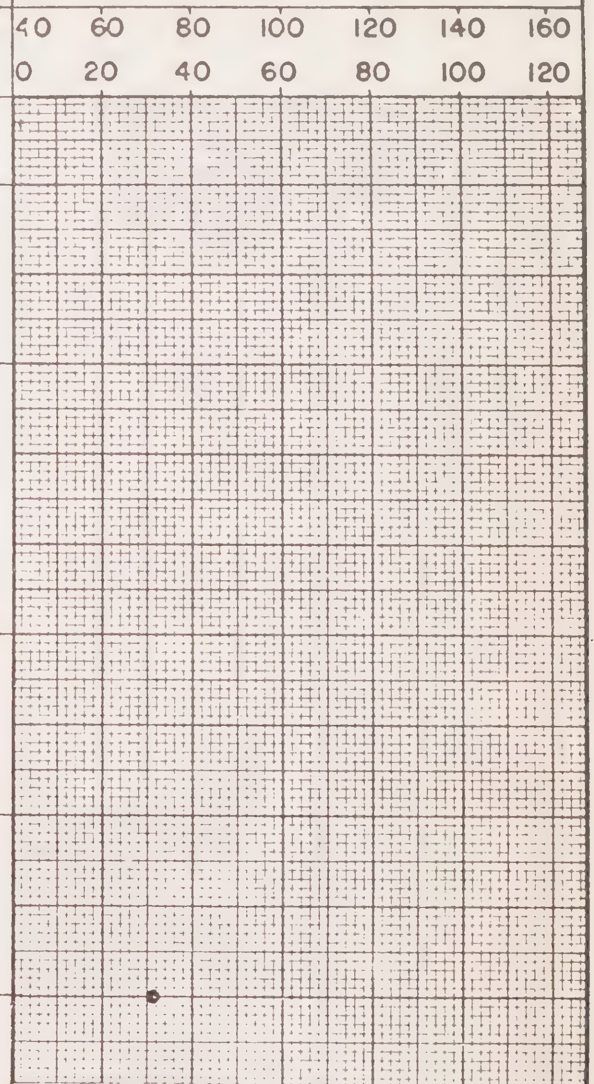
DRY DENSITY p.c.f. X
WATER CONTENT % ●



eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 5 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
MUSKEG - frozen		0	
- unfrozen saturated		1	
		2	
- frozen		3	Vx ≈ 50%
		4	
		5	
SILTY CLAY - frozen		6	Vx ≈ 65%
- rocks till?		7	
		8	Vx ≈ 20%
- rocks		9	
		10	

DRY DENSITY p.c.f. X
WATER CONTENT % ●



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PROJECT
Norman Wells Subdivision

E-545

DATE Nov. 10/72
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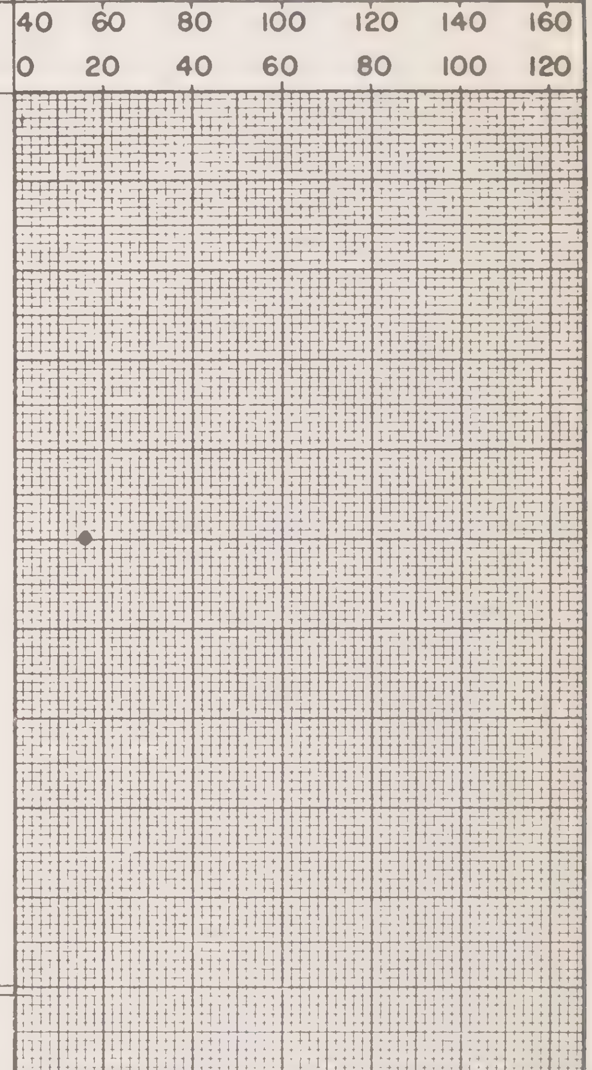
ELEVATION N.A.
DEPTH 20'

HOLE NO. 6

SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
SHALE - silty & sandy, grey, frozen		11	
- rocks		12	
		13	
		14	
- rocks		15	
		16	
		17	
		18	
		19	
		20	
END OF HOLE			

DRY DENSITY p.c.f. X
WATER CONTENT % ●



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 10/72

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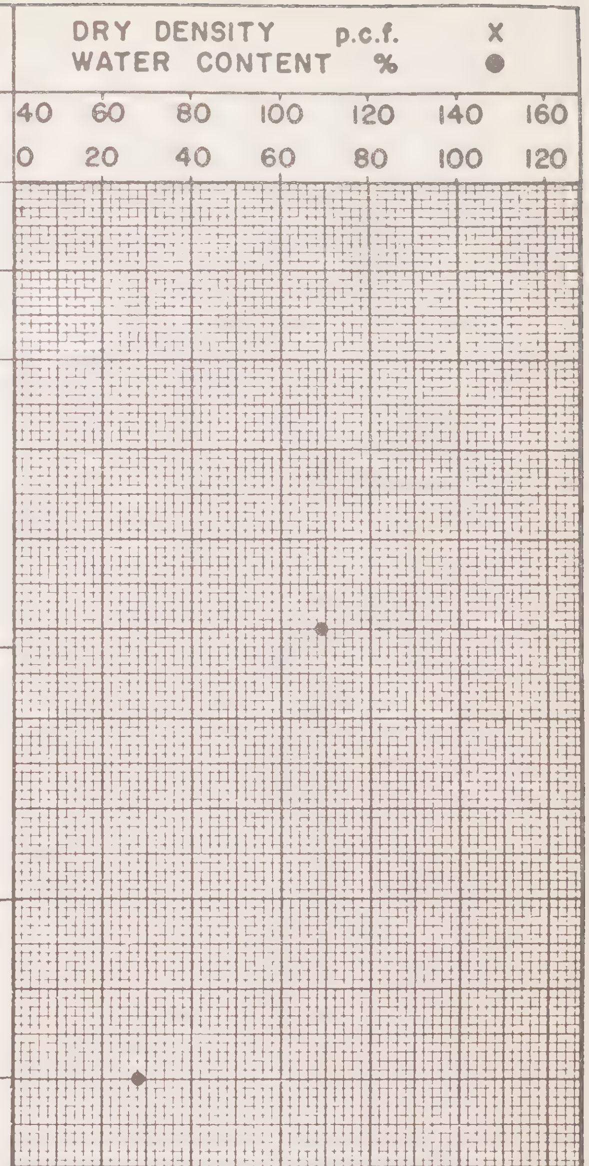
ELEVATION N.A.

DEPTH 20'

HOLE NO. 6

SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		0	
MUSKEG - frozen			
- thawed		1	
- frozen		2	
		3	
		4	
		5	
SILTY CLAY - siltier with depth frozen		6	Vx ≈ 25%
		7	
		8	Nbn
		9	
		10	



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 10/72

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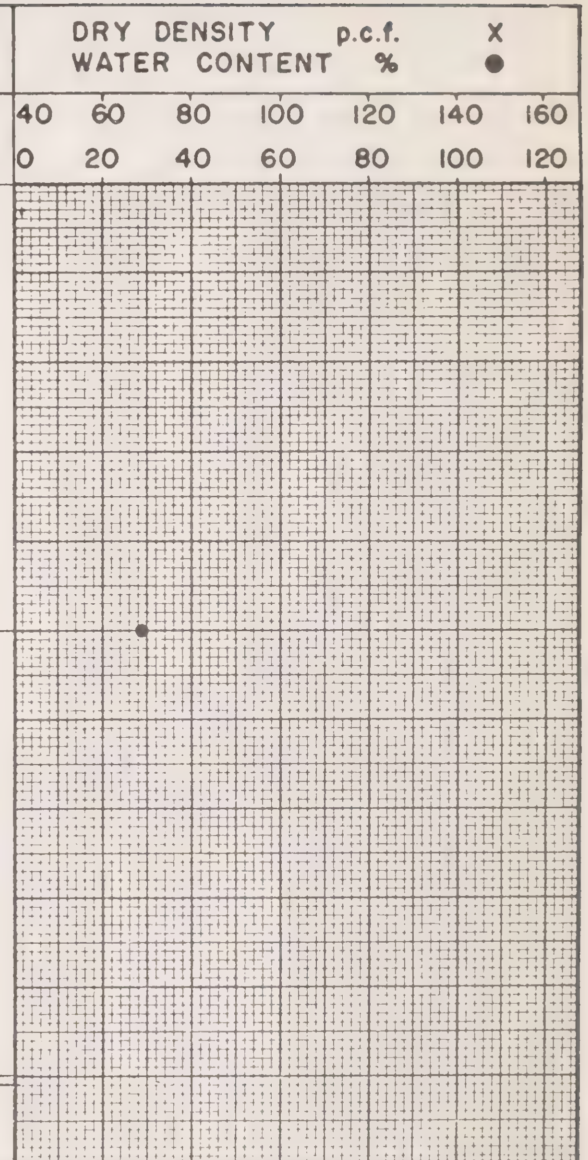
ELEVATION N.A.

DEPTH 20'

HOLE NO. 7

SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
		11	
- greyer		12	
		13	
- rocks		14	
		15	
SHALE - sandy & silty grey			Nbn
		16	
		17	
		18	
		19	
		20	
END OF HOLE			



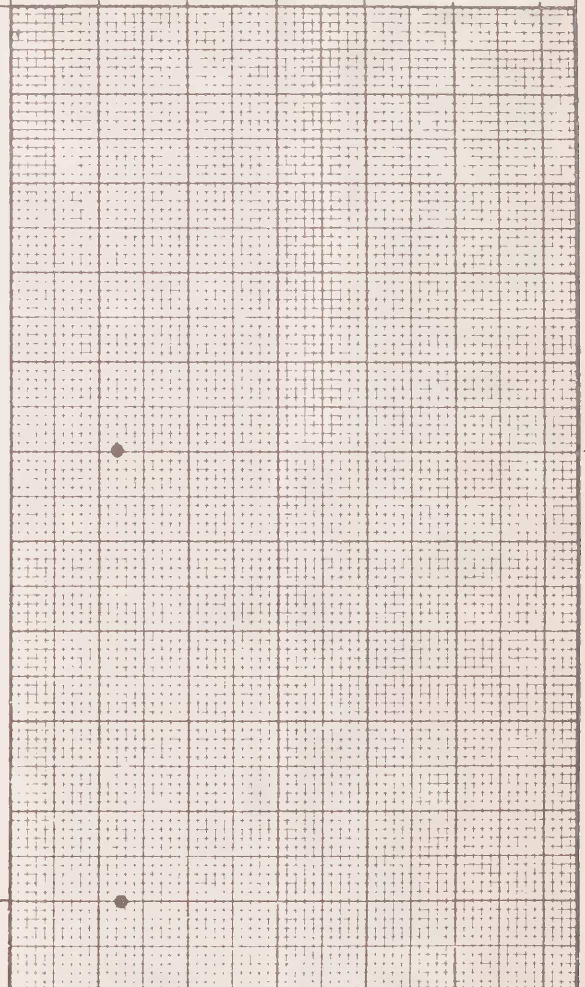
eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 10/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 7 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
SILT - sandy frozen to 6" some clay saturated mottled thawed		0	
		1	
		2	
		3	
		4	
		5	
		6	
		7	
		8	
		9	
		10	

DRY DENSITY p.c.f. X
WATER CONTENT % ●

40 60 80 100 120 140 160

0 20 40 60 80 100 120



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PROJECT
Norman Wells Subdivision

E-545

DATE Nov. 9/72

LOGGED BY H.C.

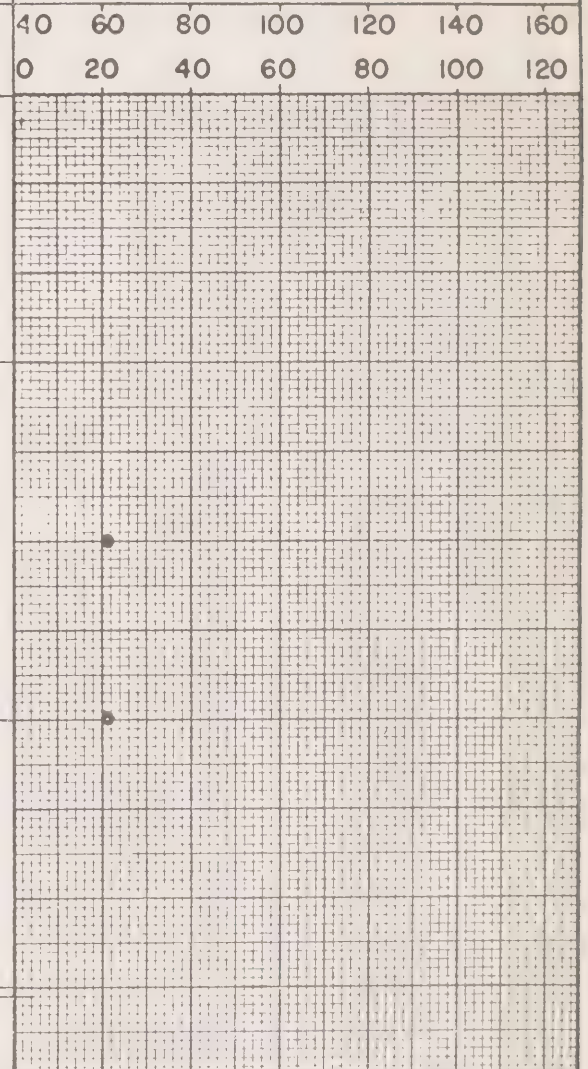
ELEVATION N.A.

DEPTH 20'

HOLE NO. 8

SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
		10		
		11		
CLAY - silty mottled brownish grey - frozen below 13'		12		
		13	Vx ≈ 20%	
		14		
		15		
		16		
SHALE - sandy & silty grey frozen		17	Nbn	
		18		
		19		
END OF HOLE NOTE: (1) Hole sloughed to 2' @ 0 Hrs.		20		



	PROJECT			
eba civil engineers	Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 8 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
				40 60 80 100 120 140 160
				0 20 40 60 80 100 120
MUSKEG - frozen to 1'		0		
- thawed saturated		1		
		2		
		3		
		4		
		5		
SILTY CLAY - pieces of shale grey frozen		6	Vx ≈ 25%	
		7		
		8		
		9		
		10		

eba civil engineers

PROJECT Norman Wells Subdivision

E-545

DATE Nov. 9/72

LOGGED BY H.C.

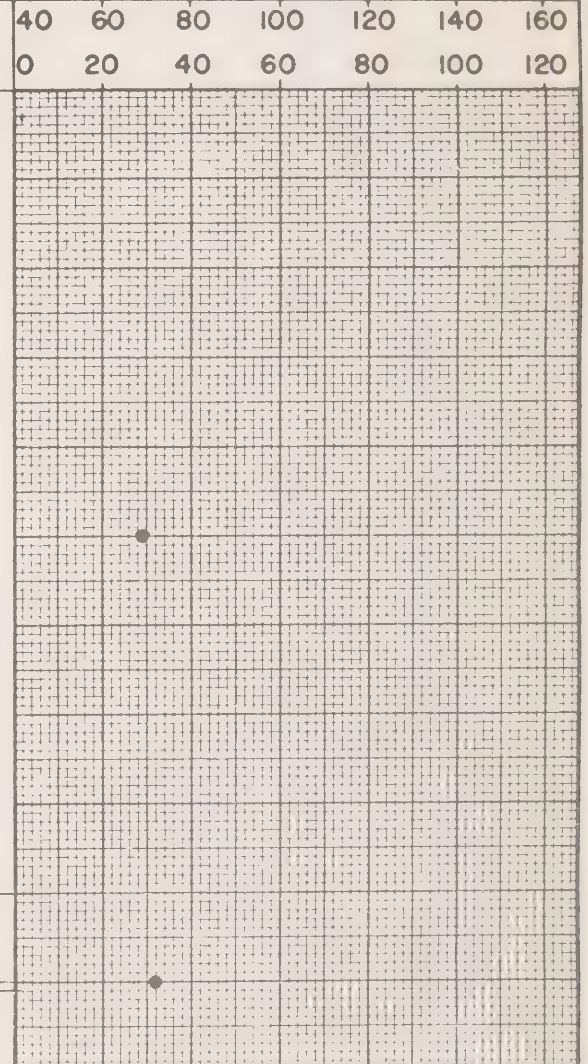
ELEVATION N.A.

DEPTH 20'

HOLE NO. 9

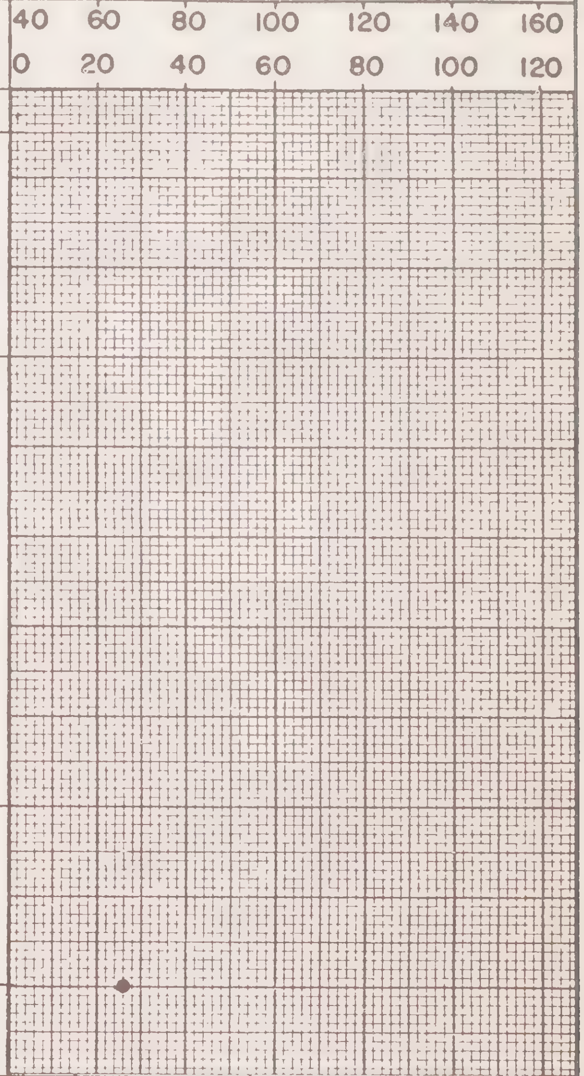
SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
		10		
		11		
		12		
		13		
		14		
		15		
		16		
		17		
		18		
		19		
SHALE - sandy & silty frozen, grey			Nbn	
		20		
END OF HOLE				



eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 9 SHEET 2 of 2

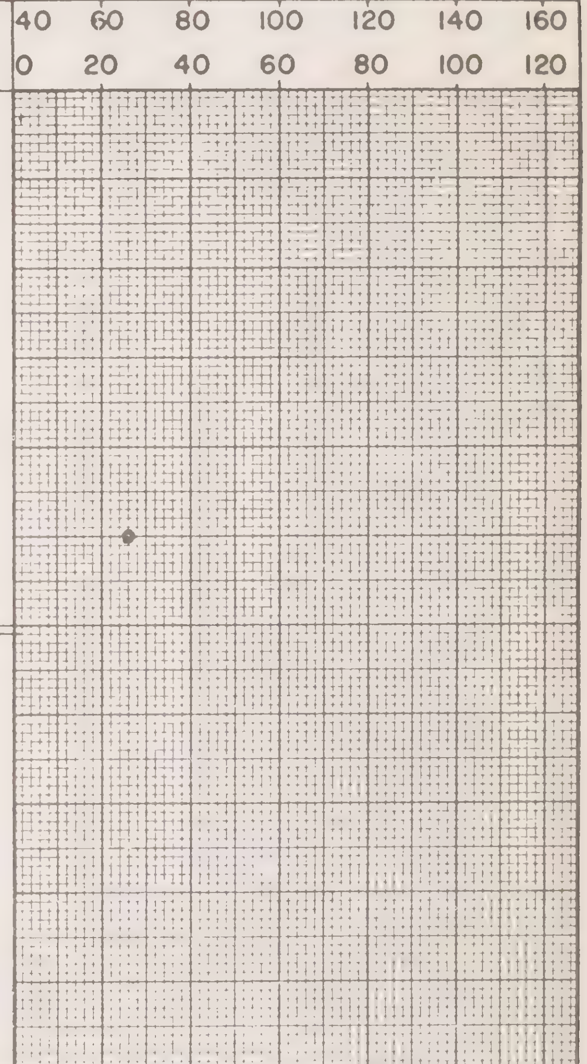
SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
		0		
MUSKEG - frozen to 6" - thawed saturated		1 2		
SAND & SILT - some clay, pieces of shale, grey, frozen		3 4 5 6 7	Vx ≈ 75%	
		8 9	Nbn	
		10		



eba civil engineers

PROJECT			HOLE NO.
Norman Wells Subdivision	DATE Nov. 9/72	ELEVATION N.A.	10
E-545	LOGGED BY H.C.	DEPTH 16'	SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
		10		
		11		
		12		
		13		
		14		
		15		
- refusal on rock				
END OF HOLE		16		



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 9/72

LOGGED BY H.C.

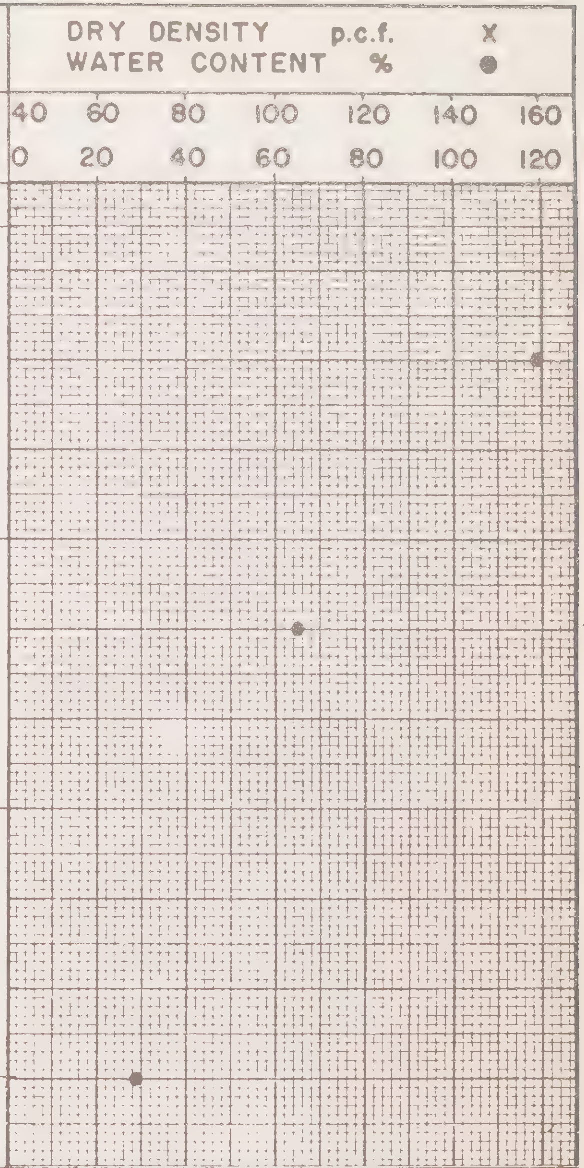
ELEVATION N.A.

DEPTH 16'

HOLE NO. 10

SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
MUSKEG - frozen to 6"		0	
- saturated thawed		1	
		2	
CLAY - silty sandy mottled frozen below 4'		3	
		4	Vx ≈ 25%
		5	
		6	
		7	Nbn
		8	
		9	
		10	

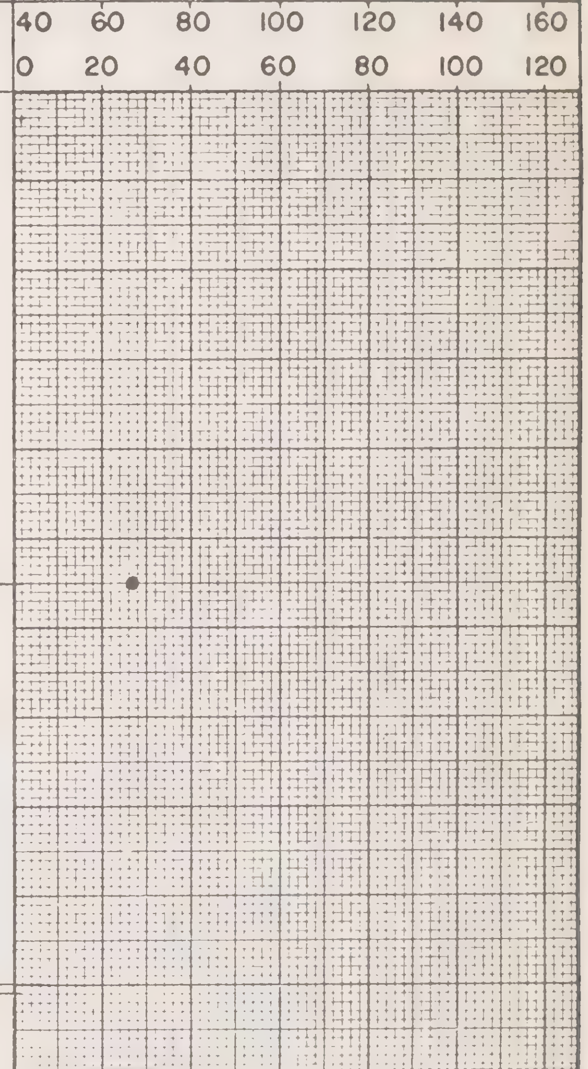


eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'

HOLE NO. 11

SHEET 1 of 2

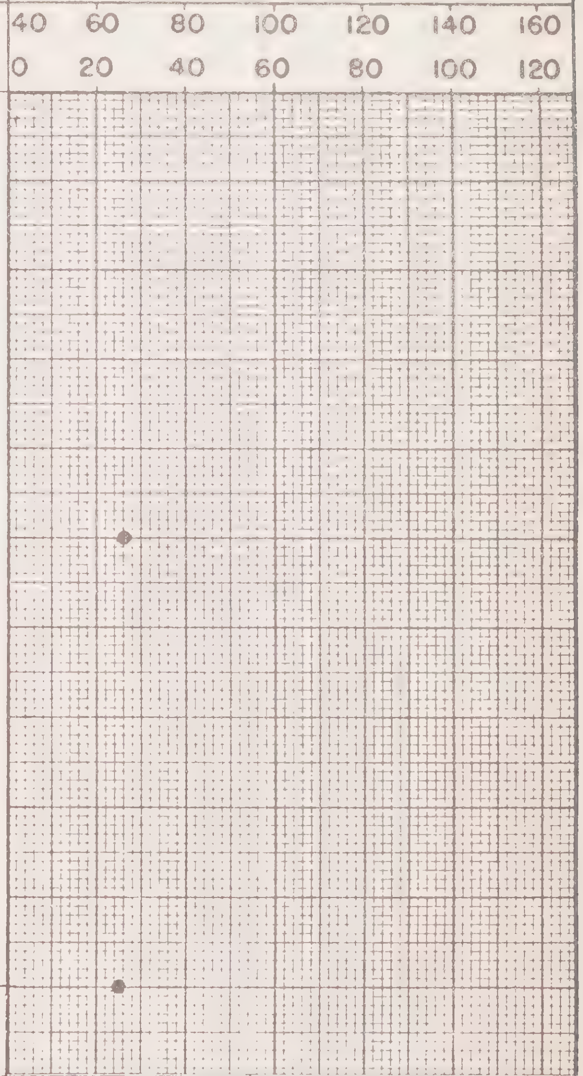
SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (N R C)
		10	
		11	
		12	
		13	
		14	
SHALE - sandy & silty, grey, frozen		15	
		16	Vx ≈ 10%
		17	
		18	
		19	
END OF HOLE		20	



eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'
			HOLE NO. 11 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
SAND - silty, saturated, mottled, thawed		0 – 5	
SILT - saturated, mottled, thawed - rocks		5 – 10	

DRY DENSITY p.c.f. X
WATER CONTENT % ●



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 9/72

LOGGED BY H.C.

ELEVATION N.A.

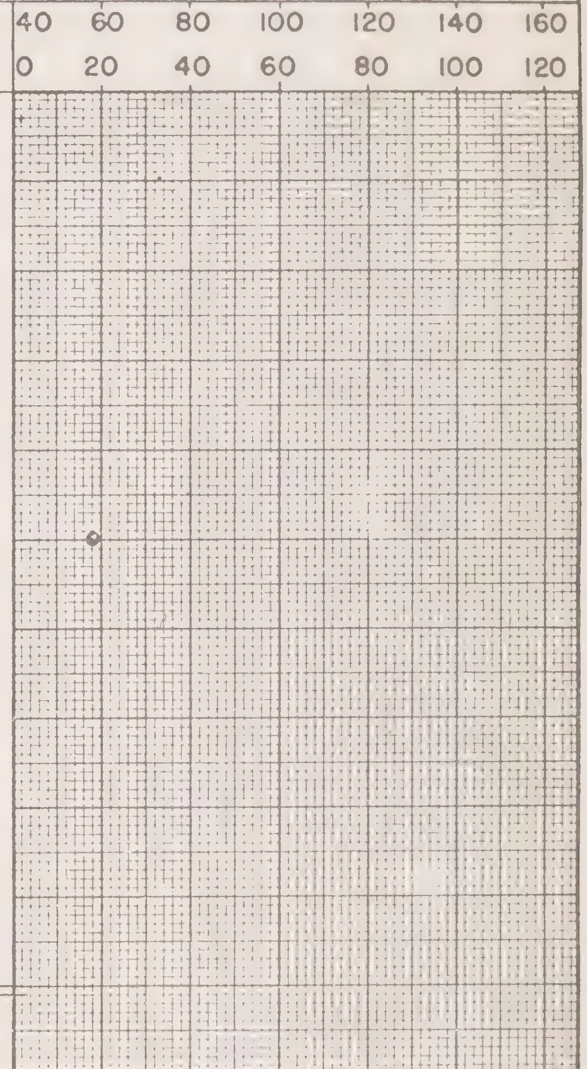
DEPTH 20'

HOLE NO. 12

SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
		11	
		12	
		13	
		14	
		15	
SHALE - sandy & silty grey thawed		16	
		17	
		18	
		19	
		20	
END OF HOLE NOTE: (1) Hole sloughed to 6' @ 0 Hrs			

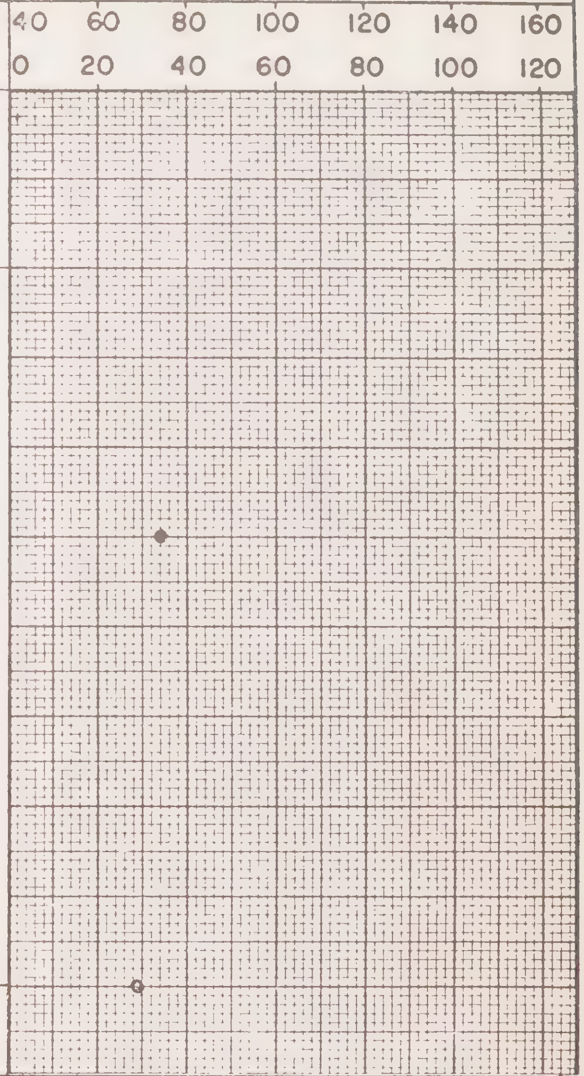
DRY DENSITY p.c.f. X
WATER CONTENT % ●



civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 9/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 12 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
MUSKEG - frozen		0 – 2	Vx ≈ 20%
SILTY CLAY - mottled some organics		2 – 10	Vx ≈ 20%

DRY DENSITY p.c.f. X
WATER CONTENT % ●



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PROJECT
Norman Wells Subdivision

E-545

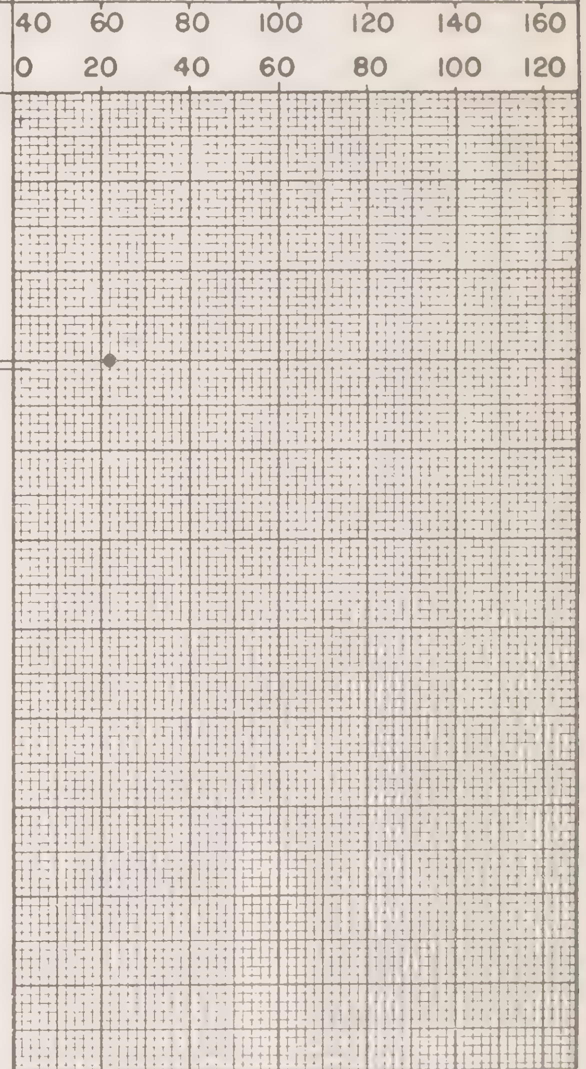
DATE Nov. 10/72
LOGGED BY H.C.

ELEVATION N.A.
DEPTH 13'

HOLE NO. 13

SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
SILT - mottled grey		10		
		11		
		12		
- refusal on rock		13		
END OF HOLE				



eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 10/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 13'	HOLE NO. 13 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
				40 60 80 100 120 140 160
				0 20 40 60 80 100 120
SAND - frozen to 1' - thawed saturated fine grained brown some silt		0 1 2 3 4 5		
SILTY CLAY - thawed grey saturated mottled		6 7 8 9 10		

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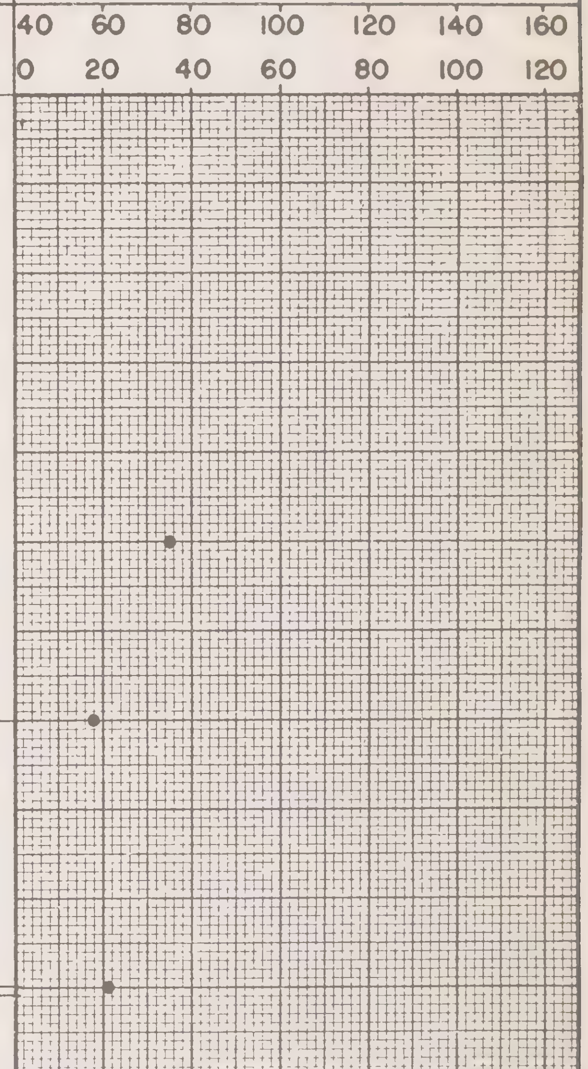
PROJECT	DATE	ELEVATION	HOLE NO.
Norman Wells Subdivision	Nov. 10/72	N.A.	14
E-545	LOGGED BY H.C.	DEPTH 20'	SHEET 1 of 2

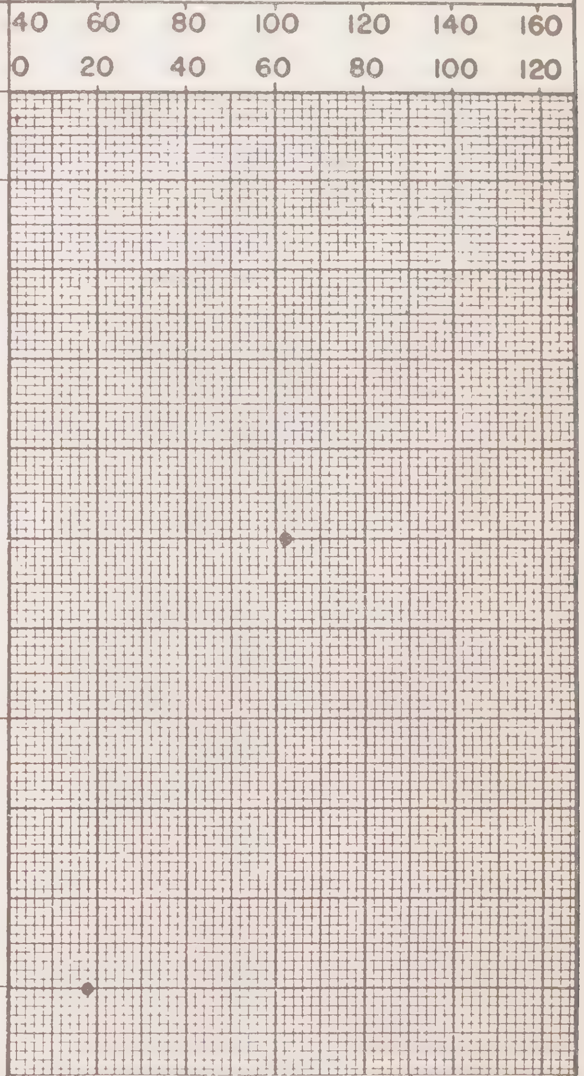
SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
- frozen pieces of shale		10–17	Vx ≈ 15%	
SHALE - sandy & silty grey frozen		17–20	Nbn	
END OF HOLE		20		



eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 10/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 14 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		0	
MUSKEG - frozen		1	
SILTY CLAY mottled frozen		2 3 4 5 6	Vx 25%
SILT unfrozen pieces of shale grey		7 8 9 10	

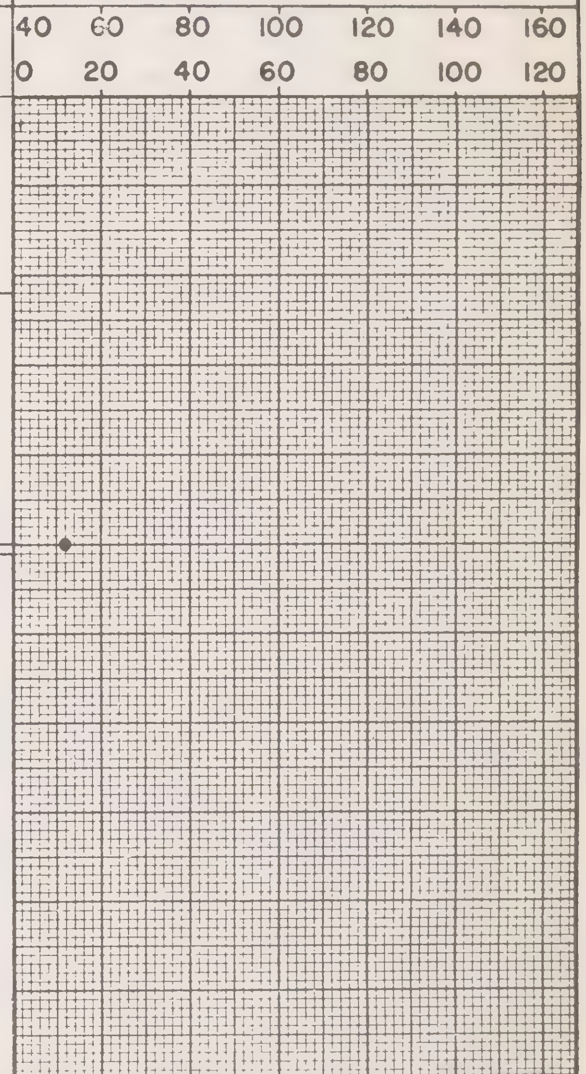
DRY DENSITY p.c.f. X
WATER CONTENT % ●



eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 10/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 15'	HOLE NO. 15 SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
		11	
		12	
SHALE - silty & sandy		13	Vx ≈ 10%
		14	
		15	
END OF HOLE			

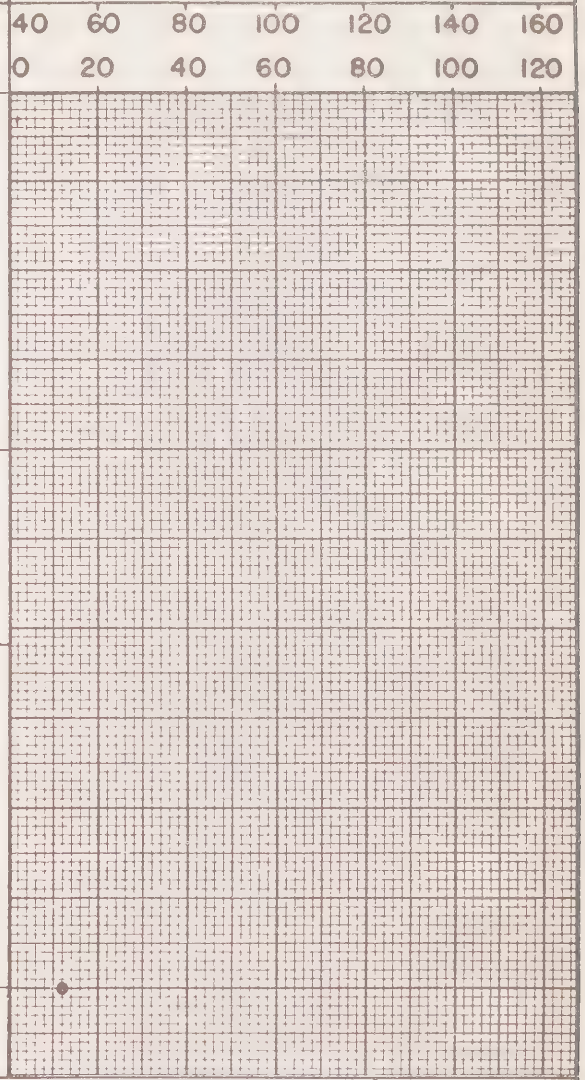
DRY DENSITY p.c.f. X
WATER CONTENT % ●



civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 10/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 15'	HOLE NO. 15 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
MUSKEG - frozen		0–4	Vx ≈ 20%
		4–6	Ice + ≈ 90%
SILTY CLAY unfrozen grey		6–9	
- frozen		9–10	Nbn

DRY DENSITY p.c.f. X
WATER CONTENT % ●



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 20/72

LOGGED BY H.C.

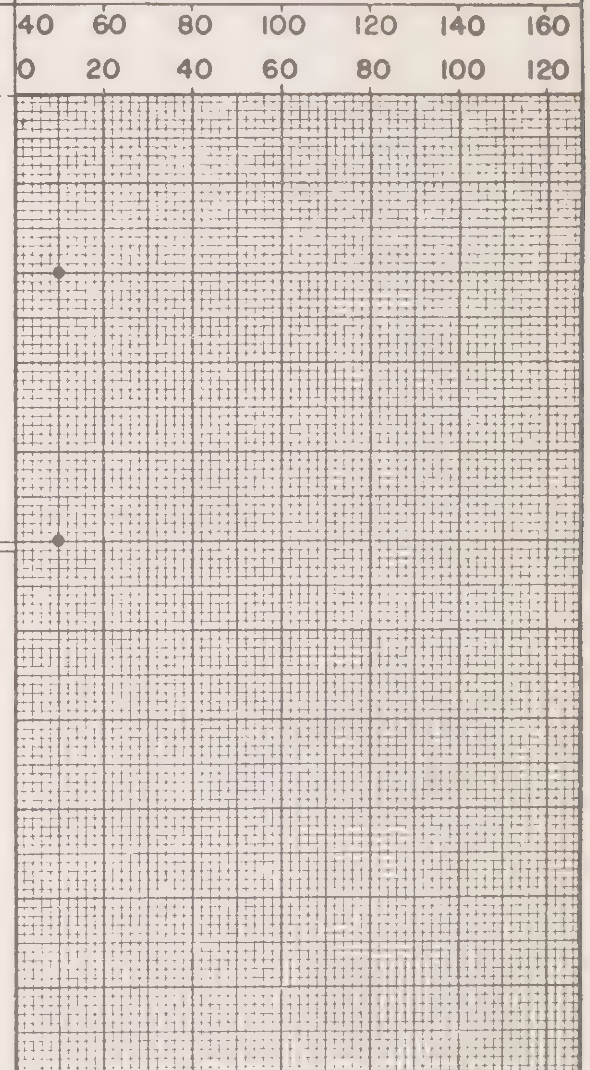
ELEVATION N.A.

DEPTH 15'

HOLE NO. 16

SHEET 1 of 2

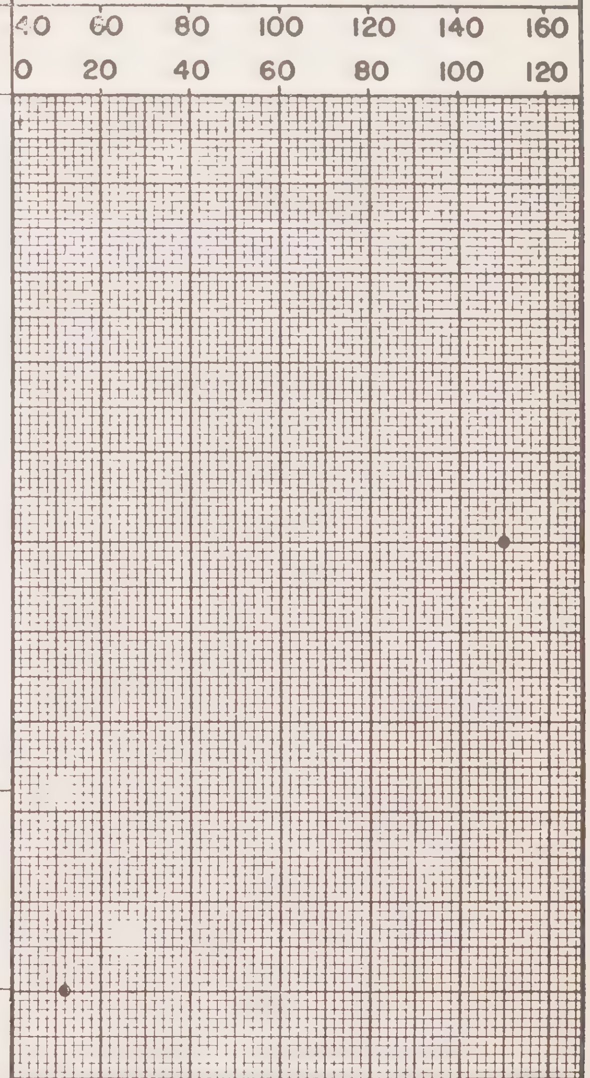
SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
		11	
SHALE - silty & sandy grey		12	Nbn
		13	
		14	
END OF HOLE		15	



eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 10/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 15'	HOLE NO. 16 SHEET 2 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
MUSKEG - frozen		0–1	Vx ≈ 50%
SILTY CLAY brown mottled frozen		1–8	
SHALE & SANDSTONE - grey frozen		8–10	Vx ≈ 10%

DRY DENSITY p.c.f. X
WATER CONTENT % ●



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 11/72

LOGGED BY H.C.

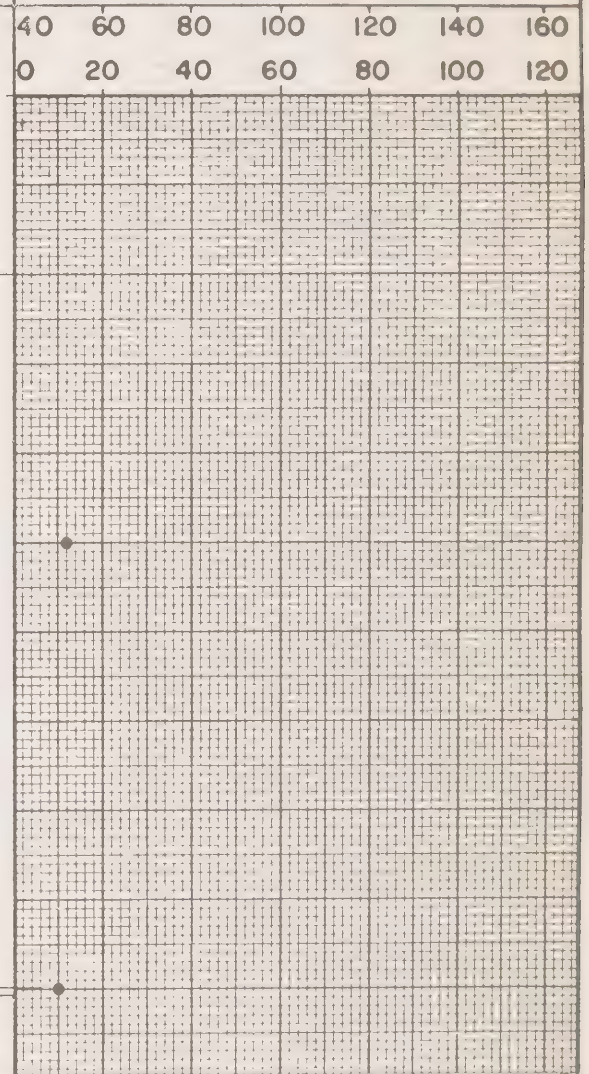
ELEVATION N.A.

DEPTH 20'

HOLE NO. 17

SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
		10		
		11		
- unfrozen very hard		12		
		13		
		14		
		15		
		16		
		17		
		18		
		19		
		20		
END OF HOLE				



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 11/72

LOGGED BY H.C.

ELEVATION N.A.

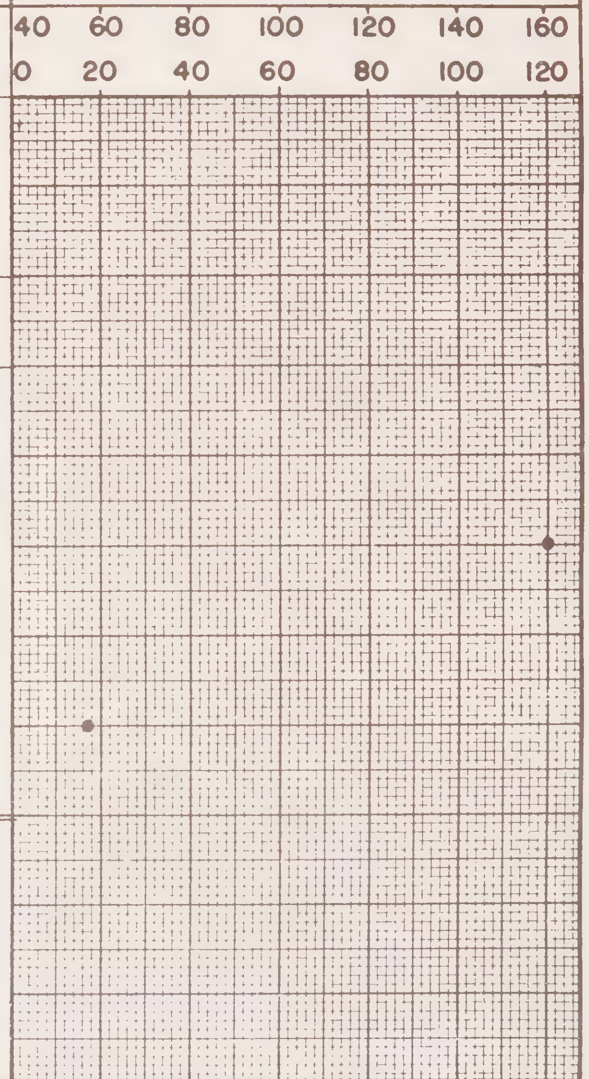
DEPTH 20'

HOLE NO. 17

SHEET 2 of 2

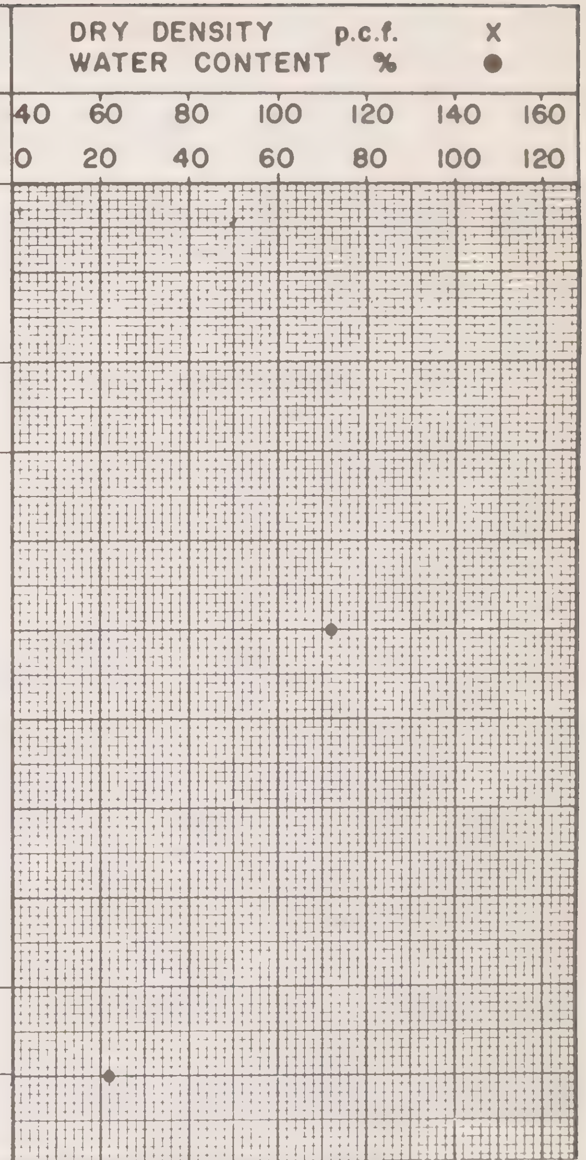
SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (N R C)
MUSKEG - frozen		0	Vx ≈ 25%
		1	
- unfrozen		2	
SILTY CLAY brown		3	Vx ≈ 50%
		4	
		5	
		6	
- refusal on rock, limestone		7	
		8	

DRY DENSITY p.c.f. X
WATER CONTENT % ●



eba civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov. 11/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 8'	HOLE NO. 18 SHEET 1 of 1

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
MUSKEG - frozen		0	Vx ≈ 30%
		1	
- unfrozen		2	
SILTY CLAY - brown frozen some organics to 5'		3	Vx ≈ 60%
		4	
		5	
		6	
		7	
		8	
SILTY CLAY - gravelly till?		9	Vx ≈ 20%
		10	



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PROJECT Norman Wells Subdivision

E-545

DATE Nov. 10/72

LOGGED BY H.C.

ELEVATION N.A.

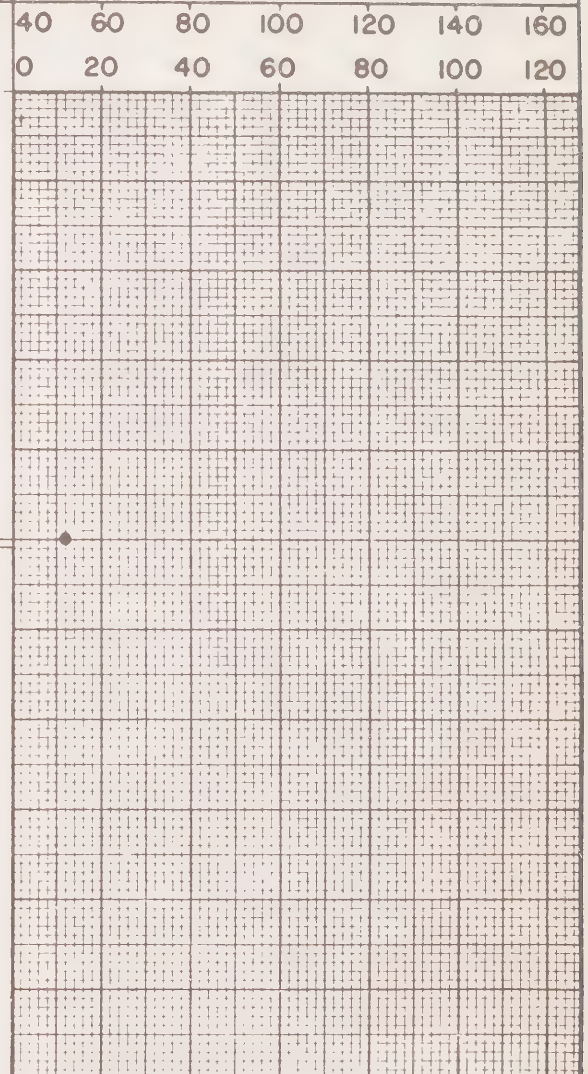
DEPTH 15'

HOLE NO. 19

SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
		10	
		11	
- rock limestone		12	
		13	
		14	
		15	
END OF HOLE		16	

DRY DENSITY p.c.f. X
WATER CONTENT % ●



civil engineers

PROJECT
Norman Wells Subdivision
E-545

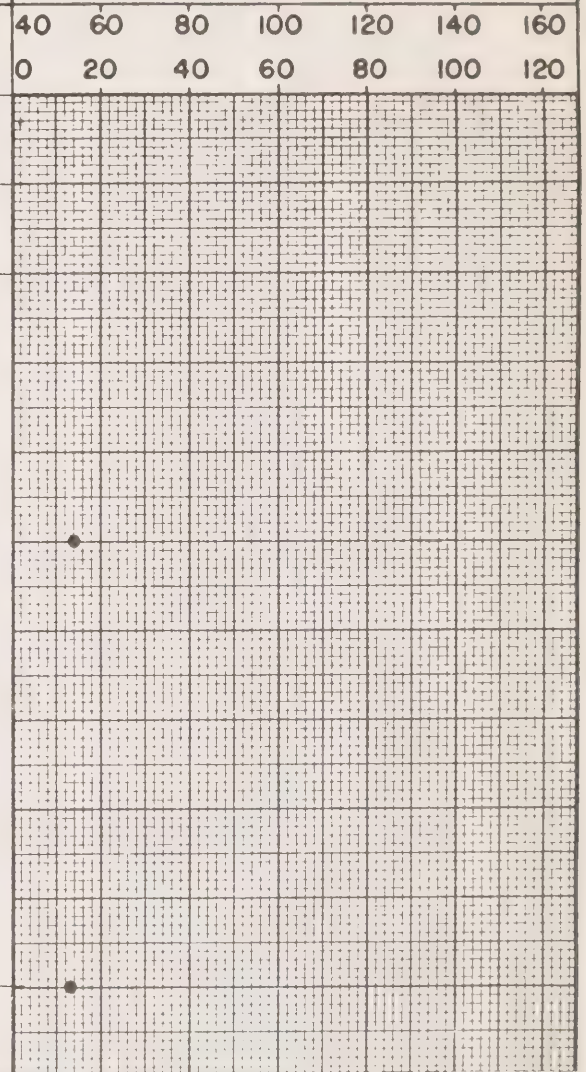
DATE Nov. 10/72
LOGGED BY H.C.

ELEVATION N.A.
DEPTH 15'

HOLE NO. 19
SHEET 2 of 2

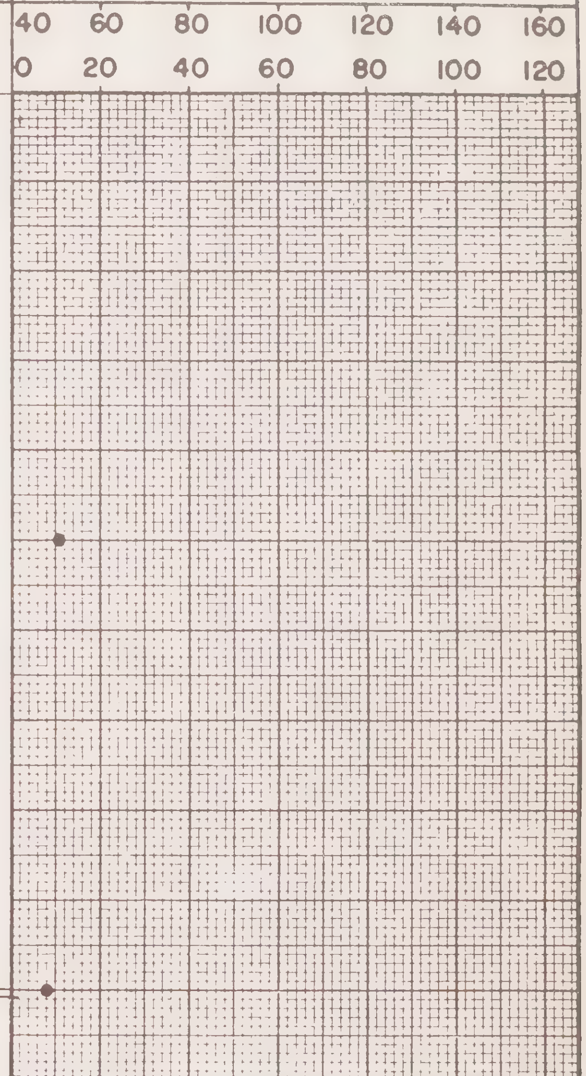
SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)
MUSKEG - frozen		0–1	
SILTY CLAY frozen to 2' - unfrozen - pieces of shale brown		1–6	Vx ≈ 30%
SHALE - sandy & silty some sandstone grey		6–10	

DRY DENSITY p.c.f. X
WATER CONTENT % ●



civil engineers	PROJECT Norman Wells Subdivision E-545	DATE Nov 11/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 20 SHEET 1 of 2

SOIL DESCRIPTION	SAMPLE TYPE	DEPTH FT.	ICE DESCRIPTION (NRC)	DRY DENSITY p.c.f. X / WATER CONTENT % ●
		10		
- shale continued				
unfrozen		11		
		12		
		13		
		14		
		15		
		16		
		17		
		18		
		19		
		20		
END OF HOLE				



eba civil engineers	PROJECT Nerman Wells Subdivision E-545	DATE Nov. 11/72 LOGGED BY H.C.	ELEVATION N.A. DEPTH 20'	HOLE NO. 20 SHEET 2 of 2

APPENDIX "H"

SOILS INVESTIGATION - NEW TOWNSITE

SITE 3

R.M. HARDY & ASSOCIATES LTD.

INTRODUCTION

At the request of Mr. W. D. Lloyd, P.Eng. of W. J. Francl & Associates Ltd., R. M. Hardy & Associates Ltd. undertook a soils investigation at the site of a proposed expansion of the Town of Norman Wells, N.W.T.

The purpose of the investigation was to ascertain the soil and permafrost conditions and to assess the suitability of the area for the proposed town site.

Eight test holes were drilled between March 20 and March 23, 1974 at the locations shown on Plate 1, Appendix A. The drill rig was a Mayhew 1000. The drilling fluid was compressed air. Five of the test holes were drilled on existing trails or seismic lines while the remaining three test holes (numbers 4, 5, 6) were drilled in virgin ground.

Disturbed samples were taken at 2 foot intervals in all test holes. No core samples were obtained for this stage of the project. Sampling was carried out by personnel from the client's office.

At the time this report was prepared, no details were available on the type or size of buildings to be erected at this site. It was assumed, for the purpose of preparing this report, that the site would be occupied by: houses, offices, apartment buildings, workshops, administrative and recreational buildings.

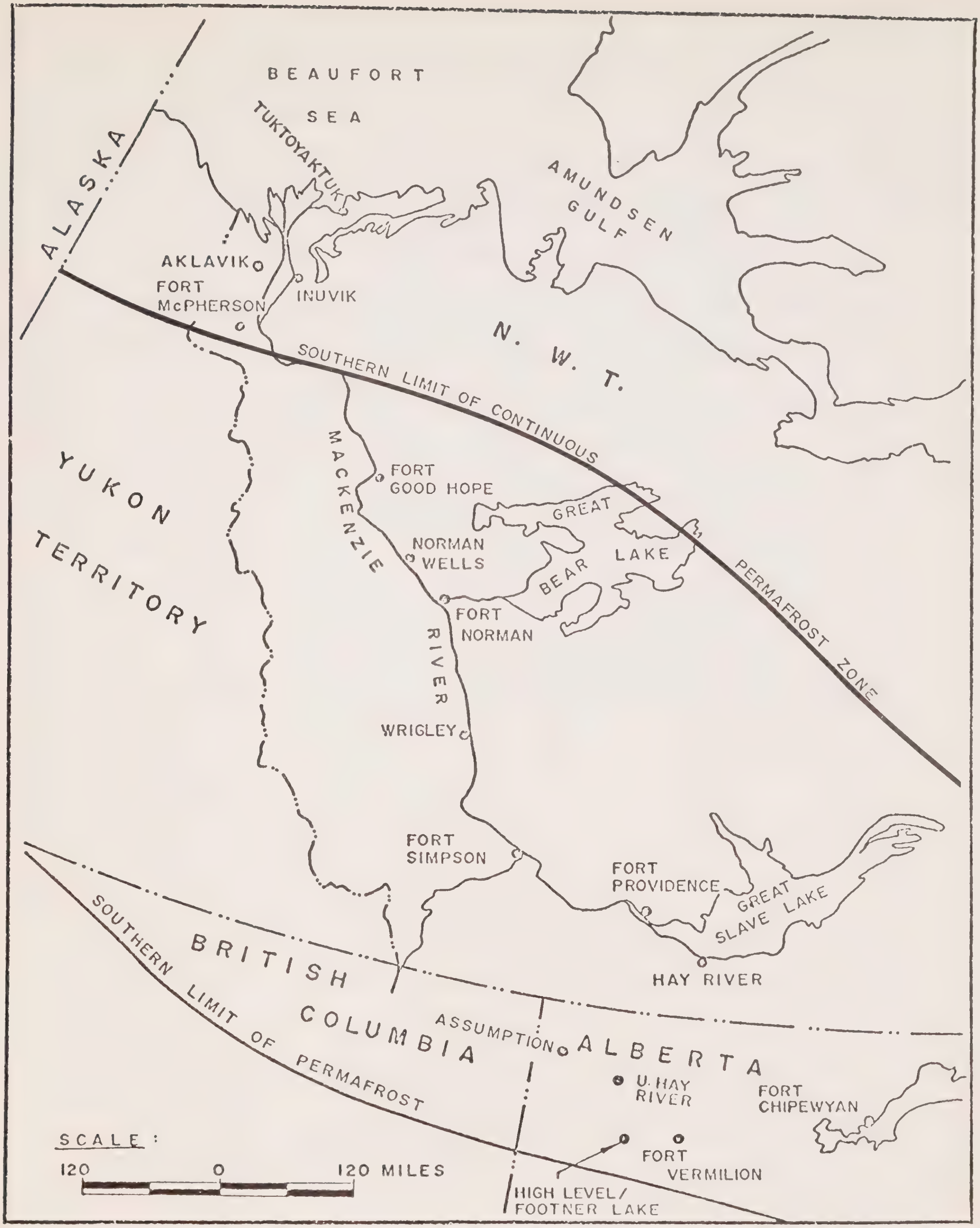
CLIMATE

Norman Wells lies within the sub-Arctic. Figure 1, following page, shows the relationship of Norman Wells to the principle settlements of the Mackenzie Valley and the southern limits of continuous and sporadic permafrost. The climate is characterized by long, cold winters and short, relatively cool summers. Precipitation is low. Weather records have been taken at Norman Wells since 1944. The climatological data are as follows:

mean annual temperature:	20.8 F
mean annual snow fall:	40 inches
mean annual rain fall:	7 inches
mean annual total precipitation:	11 inches
freezing index, mean:	7200 degree days F
freezing index, lowest value recorded:	6000 degree days F
freezing index, highest value recorded:	8000 degree days F
thawing index, mean:	3000 degree days F
thawing index, lowest value recorded:	2500 degree days F
thawing index, highest value recorded:	3350 degree days F

VEGETATION

The trees in the area consist of: black spruce, tamarack, birch and alder. The bushes consist of: laborador tea, alder and berry plants. Reindeer moss is very common while sphagnum moss is found in poorly drained areas. Trees in excess of 30 feet in height are generally found only immediately adjacent to ponds and creeks.



PRINCIPAL SETTLEMENTS

MACKENZIE VALLEY

E-2616 G Mc April 23, 1973 Figure 1

PERMAFROST

Norman Wells lies within the region of discontinuous permafrost. Permafrost is invariably found wherever the original black spruce forest has been left undisturbed. Permafrost is not found beneath rivers or lakes. The depth to the bottom of the permafrost is believed to be about 150 feet. Experience in the area has shown degradation of the permafrost table will proceed relatively rapidly once the organic surface cover is removed or disturbed. It is possible that the depth of degradation of the permafrost could be as much as 30 feet in a period in less than 10 years.

There are two causes of vertical movement in structures founded in permafrost conditions. The first type of movement is settlement due to thawing of the ice-rich soil while the second cause is heaving due to frost action in the active layer during the winter.

SOIL PROFILE

The typical soil profile at the site consists of organic soil, sometimes peat, overlying till. Layers of silt, sand and gravel are quite commonly found enclosed within the clay till. The log of Test Hole 1, Appendix A, is typical of the soil profile where only organic soils and clay till are found. The log of Test Hole 6 is typical of the soil strata where the other soils

types are also found.

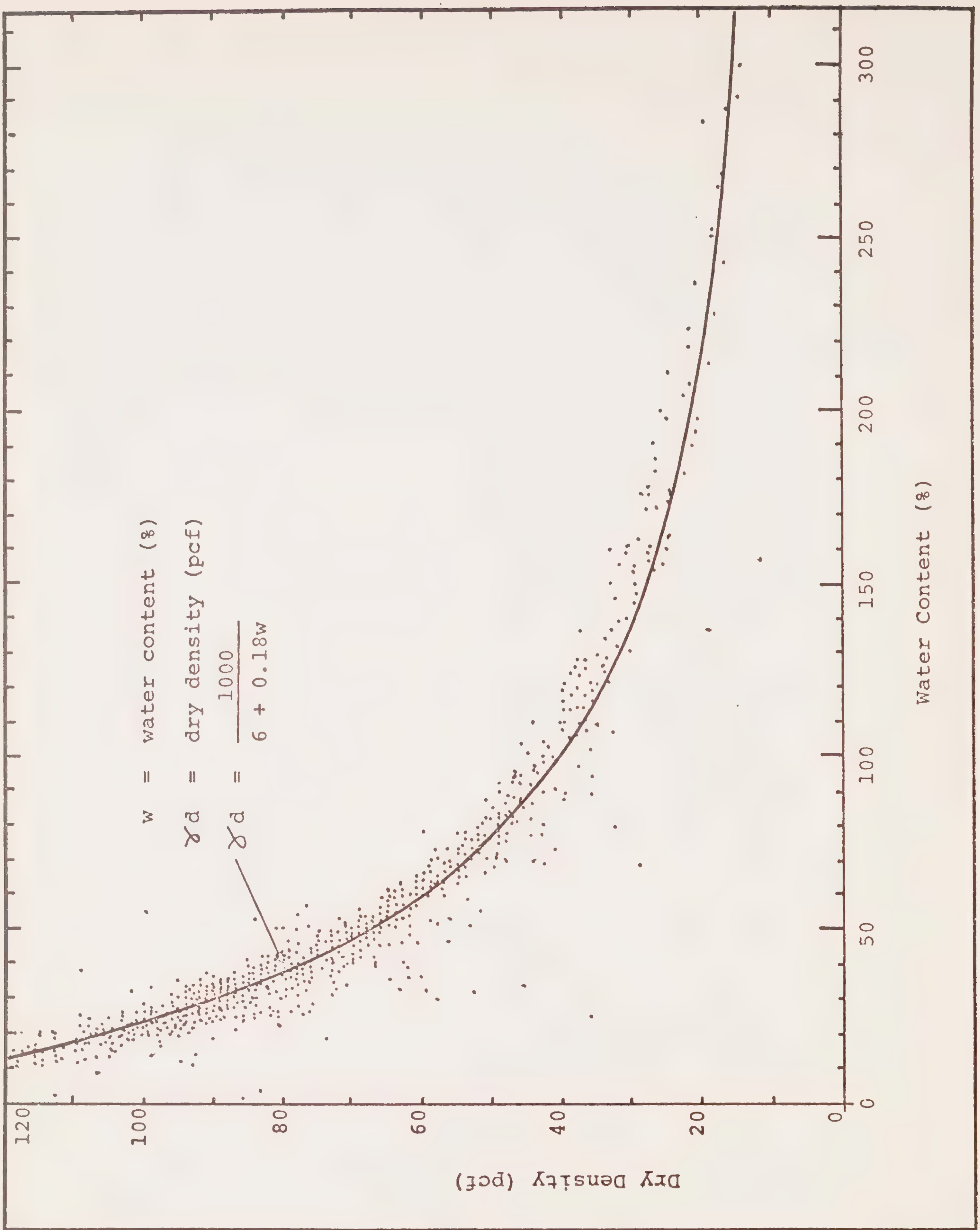
Water contents are generally high within the top 5 feet of the soil profile but are generally below 20 percent below that depth. Test Holes 3, 4 and 6 showed water contents higher than 20 percent but generally below 30 percent. In Test Hole 6, at a depth of 30 feet, one soil sample had a water content of 65 percent. Such a high water content at this depth is most unusual in the Norman Wells area and was probably due to isolated ice lenses.

Figure 2, following page, shows the relationship of dry density to water content of permafrost soils in the Mackenzie Valley. While there is considerable catter in the measured field data it can be stated as a general rule that permafrost soils with a water content of less than 20 percent will generally display only small settlements on thawing.

The bedrock in this area consists of shale with interbedded sandstone stringers. None of the test holes in this program penetrated to bedrock. The depth to bedrock at the present town site of Norman Wells varies from 28 to 33 feet.

DISCUSSION AND RECOMMENDATIONS

As stated above, settlement in thawing soils where the water content is less than 20 percent will be quite small. Therefore, degradation of the permafrost



R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

MACKENZIE VALLEY SOILS
DRY DENSITY VERSUS
WATER CONTENT

SCALE	DATE	MADE	CHKD.	JOB:	PLATE

Figure 2

beneath roads would not give rise to serious problems. However, even the small settlements which are anticipated would be sufficient to cause structural distress in most buildings.

Degradation of the permafrost cannot be prevented once construction has commenced. Due to the low water contents in the soil, and consequent relatively high thermal conductivities, permafrost degradation would be relatively rapid.

Building Foundations

For small buildings a suitable foundation would be a gravel pad of at least 2 feet in thickness, with the building placed on top resting on cribs or blocks of wood. If the necessitity for relevelling such a building at periodic intervals is accepted such a foundation will be quite satisfactory. However, this type of foundation is recommended only for small buildings of timber frame and no more than one storey in height.

For larger buildings, or where periodic levelling is not acceptable, a pile foundation is the best solution. The main problem will not be the support of the dead and live loads of the structure but rather to eliminate the possibility of any piles being heaved as the result of degradation of the permafrost table combined with heaving of the ground during the winter. The minimum depth of embedment of piles should be 30 feet. All

piles should be driven, not placed in predrilled holes, so that only steel piles are likely to be economical. Timber piles would be unable to withstand the driving stresses while precast concrete piles are unlikely to be economical.

A type of pile which has been used with great success in similar ground conditions is drill stem which is available at some locations at salvage prices. Drill stem is available in 30 foot lengths. The minimum outside diameter should be 4 inches. Thick walled steel pipes may also be used and, for exceptionally heavy loads, it may be economical to use steel H- piles.

Driven steel piles should be designed on the basis of an allowable skin friction of 300 psf.

Where possible, all buildings should be placed clear of the finished ground surface so as to leave an air space equal in height to 1/10 of the width of the building with a minimum height of 3 feet. Where the building is more than 50 feet in width the height of the air space can be 5 feet. The floors of all buildings should be insulated. A gravel pad should be placed under all buildings which are clear of the ground. The function of the gravel pad is to ensure that no water is allowed to run under the building or to remain there at any time.

Where the main floor of the building is to be placed at grade level, settlements of the floor should be expected. For offices and schools the main floor should be supported structurally by the foundation and should not rely on the subgrade for support. Basements can be provided for houses but it will be necessary to support the basement wall on piles. The basement floor slab should preferably be a structural floor. If the basement floor slab is to rest on the subgrade, some settlement must be anticipated by the designer.

If heavy trucks or equipment are to be overhauled or maintained in a garage, a pile foundation for the floor would probably not be economical due to the heavy structural loads. In this case the building can be seated on a gravel pad. The walls of such buildings should be supported on piles. Relevelling of the garage floor can be carried out at periodic intervals. If a concrete floor is placed in such a building, it must be entirely separate from the walls and columns and should be cast in relatively small sections.

Site Grading

In order to ensure that a supply of water required for frost heaving is not made available, the sites of all buildings should be graded so as to shed excess water from rain or snow melt as quickly as possible.

Fill

Fill placed beneath structures, or in parking or material storage areas, should be compacted as well as the available equipment permits. It is imperative that rain or melt water should not be permitted to form channels but should leave the site as close to the surface as possible. We suggest that gravel fill should be placed in layers of 6 inches and should be compacted by means of vibratory rollers. Cobbles larger than 6 inches in diameter should be rejected from all fill as these stones will work their way to the surface by frost action.

Roads

In the latitude of Norman Wells, studies have shown that the permafrost table will degrade beneath the embankment no matter to what height the embankment is constructed. Investigations along the Canol Road have shown that the degradation of the permafrost beneath a conventional highway embankment will reach a depth of 30 feet in less than 25 years. Where there has been a considerable thickness of peat left beneath the embankment, the degradation of the permafrost took place at a much slower rate so that, in a period of 25 years, the depth of degradation was a little as 12 feet.

The design and construction procedures of road embankments in the Norman Wells area should be

based upon the assumption that some settlement due to degradation of the permafrost is inevitable. Degradation will proceed relatively rapidly at first and will then slow own. The depth to the permafrost table from the base of an embankment is roughly in proportion to the square root of time since construction commenced. This means that the time for degradation to reach a depth of 20 feet will be four times the time required for degradation to reach a depth of 10 feet.

It has been our experience, that for the area of this study, the highest ice contents are usually found just below the permafrost table. It must therefore follow that any degradation of the ground surface due to melting of the permafrost will be extremely rapid in the first few years following construction and will then proceed less rapidly until rate of degradation is imperceptible.

As leaving the surface peat layer intact will not prevent degradation but only retard it, the only advantage in leaving such peat beneath an embankment would be to prolong the time taken for surface subsidence to occur and this may be of some benefit in maintenance programs. Where high ice content soils are encountered within the subgrade, settlement of the embankment must be anticipated and must be provided for in the design

and in planning of maintenance programs. Previous exploration programs in this area have revealed occasional buried blocks of clear ice. We do not recommend attempting to locate such buried ice masses but rather to accept the possibility that they may occur.

Ditches can be used for surface drainage although the possibility of erosion due to melting of ground ice is a possibility in some locations. Where the bottom of a ditch penetrates into a layer of sand or silt severe erosion may occur on even moderate slopes. Erosion of the ditches can be prevented by lining them with gravel or by running the ditch parallel to the contours so that the gradient in imperceptible.

The local clay till will generally form a good material for road embankments. However, difficulties may arise during construction due to the short season and occasional occurrences of high ice contents in the borrow. The material that could be used for embankments include the relatively soft bedrock which can be found at the existing quarry in Kee Scarp.

Miscellaneous

A general study of problems associated with highway design and construction in the Norman Wells area was prepared by this office for the Department

of Public Works of Canada. This study is contained in Volume II of "Geotechnical Investigation, Mackenzie Highway, Mile 544 to Mile 635" dated pril 20, 1973.

Respectfully submitted,

R. M. HARDY & ASSOCIATES LTD.,

Per:

GM/jc

G. McCormick, P.Eng.

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER P 226
R. M. HARDY AND ASSOCIATES LTD.

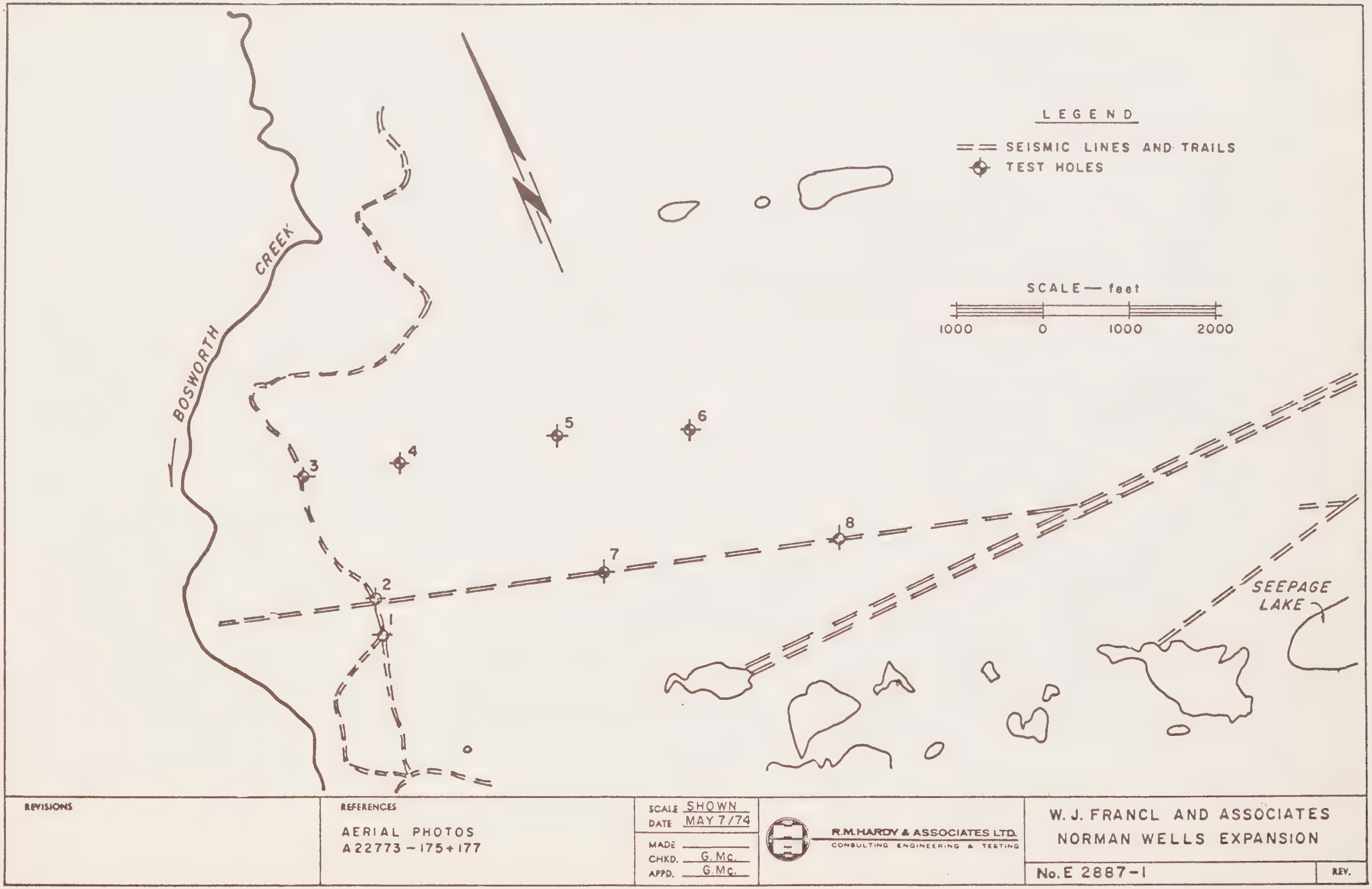

LEGEND
SEISMIC LINES AND TRAILS
TEST HOLES
SCALE — feet
1000
0
1000
2000
BOSWORTH CREEK
SEEPAGE LAKE
2
3
4
5
6
7
8
REVISIONS
REFERENCES
AERIAL PHOTOS
A22773 - 175+177
SCALE SHOWN
DATE MAY 7/74
MADE
CHKD. G.Mc.
APPD. G.Mc.
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING
W. J. FRANCL AND ASSOCIATES
NORMAN WELLS EXPANSION
No. E 2887-1
REV.

PLATE I

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

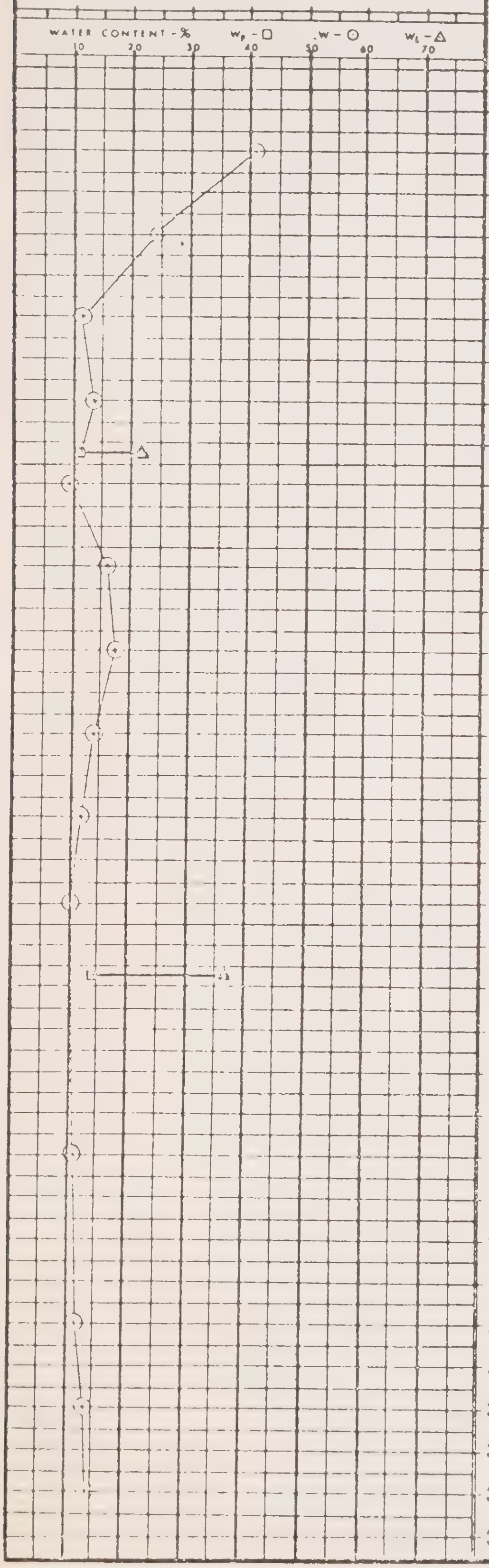
SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN A.L. | CKD G.Mc | DATE OF INVESTIGATION Mar 20/74 | JOB NO E-2887 | HOLE 1

WATER CONTENT

WATER CONTENT - % w_p - □ w - ⊙ w_L - △



DEPTH FEET	SOIL PROFILE – SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SYMBOL	UNIFIED CLASSIF	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
1	CLAY:							
2	organic,							
3	amorphous granular peat, wood fragments		Pt					
4								
5								
6	CLAY (TILL):							
7	silty, sandy, soft, low-medium plastic		CL					
8	dark brown,		CI					
9	free moisture, pebbles to ¼"							
10								
11								
12								
13	very stiff,							
14	grey brown, rust stains		CL					
15								
16								
17	dark grey, pebbles							
18								
19	calcareous							
20								
21	medium to high plastic		CI					
22								
23								
24								MA see Plate 19
25								
26								
27								
28								
29								
30								
31								
32	pebbles to 1/8" coal specks							
33								
34								
35								

PLATE 2

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN | CKD | DATE OF INVESTIGATION | JOB NO E-2887 | HOLE 1

WATER CONTENT

WATER CONTENT - % w_p - □ w - ○ w_l - △

10 20 30 40 50 60 70

DEPTH FEET	SOIL PROFILE — SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SYMBOL	UNIFIED CLASSIF	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
36								
37								
38								
39								
40								
41	End of hole at 40 ft							
42								
43								
44								
45								
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								

PLATE 3

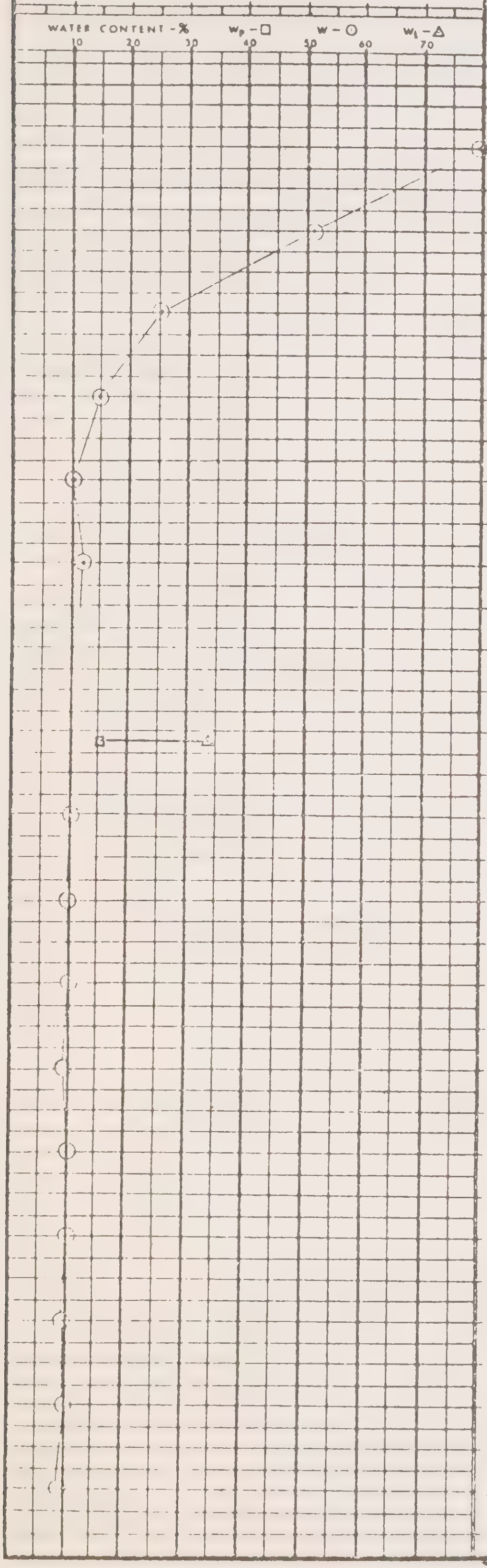
R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN	CKD	DATE OF INVESTIGATION	JOB NO	HOLE
A.L.	G. Mc.	Mar 21/74	E-2887	2

WATER CONTENT



SOIL PROFILE — SOIL DESCRIPTION

DATUM
SURFACE ELEVATION

DEPTH FEET	SOIL DESCRIPTION	UNIFIED CLASSIF.	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
1–4	PEAT black, trace of clay	Pt					
6–11	CLAY (TILL): silty, sandy high plastic, light brown, pebbles to ¼"	CH					
	med. plastic, brown, calcareous	CI					
12	low plastic, rust stains	CL					
13–14	pebbles to ½" coal specks						
15							MA see Plate 20
16–17	dark grey brown, pebbles to ¼"						
18–21	med. to high plastic, dark grey, pebbles to ½" coal specks	CI					
22		CH					
23	pebbles to ¼"						
34	pebbles to ½"						

PLATE 4

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN	CKD	DATE OF INVESTIGATION	JOB NO E-2887	HOLE 2

WATER CONTENT

WATER CONTENT - % 10 20 30 40 50 60 70 w_P - □ w - ○ w_L - △

DEPTH FEET	SOIL PROFILE: SOIL DESCRIPTION (DATUM, SURFACE ELEVATION)	SOIL SYMBOL	UNIFIED CLASSIF	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
36	dark brown							
37								
38			CI					
39								
40	dark grey							
41								
42								
43								
44								
45	END OF HOLE @ 44 ft							
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								

PLATE 5

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

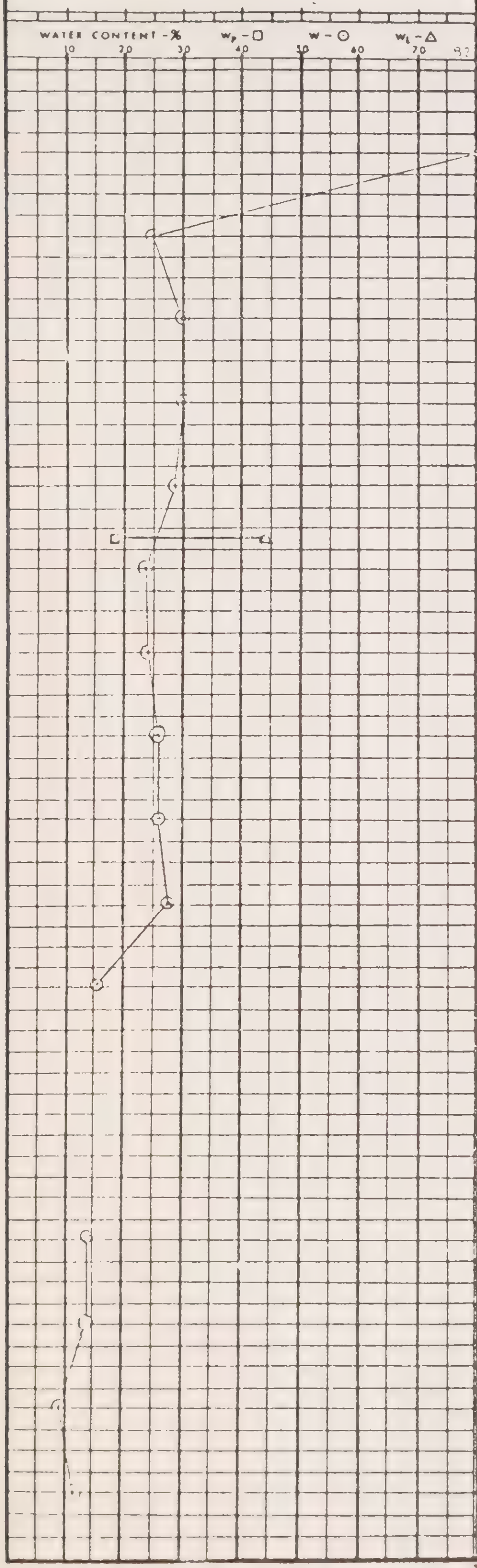
SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN A.L. | CKD G. Mc. | DATE OF INVESTIGATION Mar 23/74 | JOB NO E-2887 | HOLE 3

WATER CONTENT

WATER CONTENT -% w_p - □ w - ⊙ w_L - △



SOIL PROFILE — SOIL DESCRIPTION — DATUM — SURFACE ELEVATION

DEPTH FEET	SOIL DESCRIPTION	UNIFIED CLASSIF.
	Topsoil	
1	CLAY (TILL)	
2	sandy, silty	
	med. plastic	
3	rootlets	CI
4		
5	brown	
	calcareous	
6		
7	high plastic	CH
8	med-high plastic	
9		
10	high plastic,	Cl
11	dark grey,	
	rust stains	
12		
13		CH
14–17		
18	stiff	
19–27		
28	SAND, trace of clay	
29	low to non-plastic	SC
30	SILT, sandy, silty	
31	low plastic	ML
32	CLAY, sandy, silty	
33	medium plastic	Cl
34	SAND, silty,	
35	very low plastic	SM

SOIL SAMPLES: CONDITION | TYPE | PENETRATION RESISTANCE | RECOVERY % | OTHER TESTS

PLATE 6

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

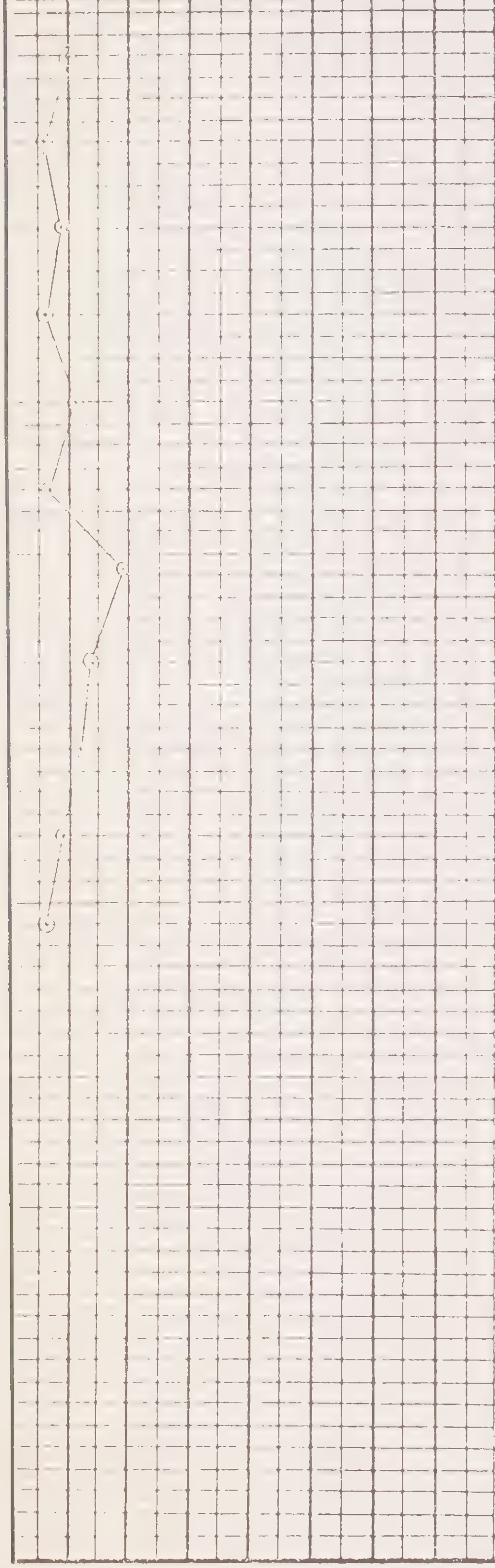
PROJECT W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN | CKD | DATE OF INVESTIGATION | JOB NO E-2887 | HOLE 3

WATER CONTENT

WATER CONTENT - % w_p - □ w - ○ w_l - △

10 20 30 40 50 60 70



DEPTH FEET	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SYMBOL	UNIFIED CLASSIF	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
36								
37–38	CLAY, silty, sandy low plastic		CL					
38–40	SAND, silty calcareous		SM					
40–44	CLAY, very silty, sandy low plastic		CL					
44–56	SAND, silty med. grained light grey, odd pebble to ½" calarcous non-plastic odd pebble to ¼" fine grained		SM					
57	END OF HOLE @ 50 ft							

Depth scale: 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70

PLATE 7

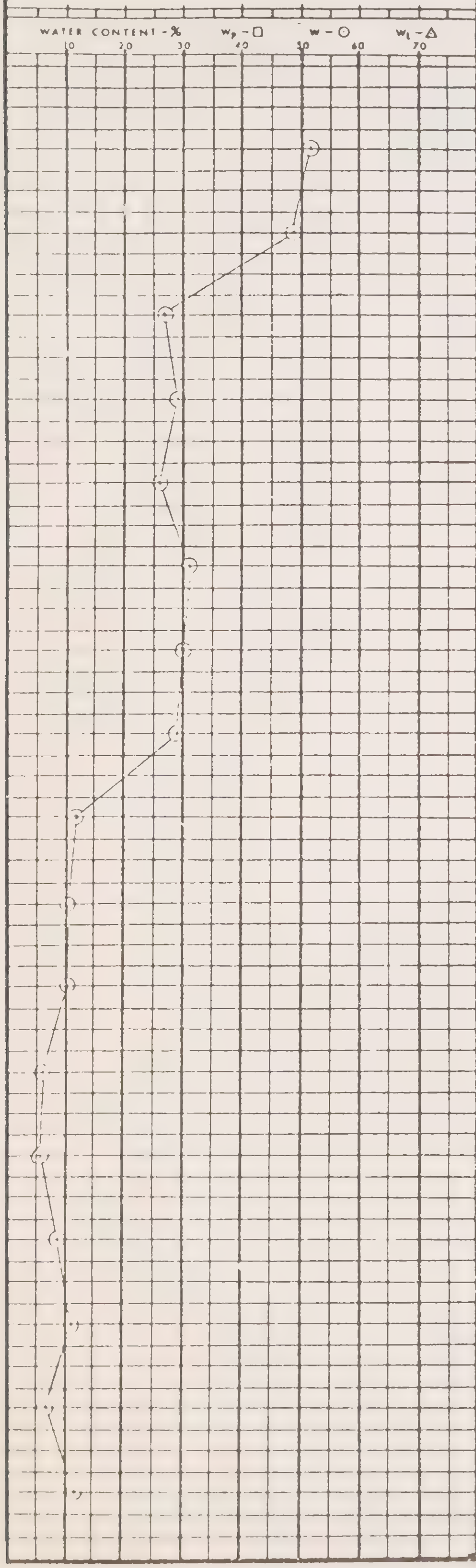
R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN A.L. | CKD G. Mc. | DATE OF INVESTIGATION mar 23/74 | JOB NO E-2887 | HOLE 4

WATER CONTENT



DEPTH FEET	SOIL PROFILE – SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	UNIFIED CLASSIF.	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
1	PEAT:						
	silty,						
2	slightly clayey,	Pt					
3	very low plastic						
	black						
4							
5	CLAY:						
	silty, sandy						
6	organic						
	low plastic						
7	calcareous	CI/					
8	brown						
9	med-high plastic						
10		Cl					
	firm,						
11	pebbles to ½"	CH					
12							
	mottled grey-brown						
13							
14							
15							
16	stiff						
17							
18	odd pebbles to ¼"						
19							
20	SILT:						
21	sandy						
22	grey						
	pebbles to ¼"						
23		MH					
24							
	pebbles to ½"						
25							
26	SAND:						
27	silty, pebbles to ½"	SM					
28	CLAY:						
29	silty, stiff	CI					
	med. plastic						
30	SILT:						
31	sandy, clayey						
32	low plastic, grey	ML					
33	pebbles to ¼"						
	grey						
34	CLAY, silty, sandy						
35	med. plastic	CI					

PLATE 8

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

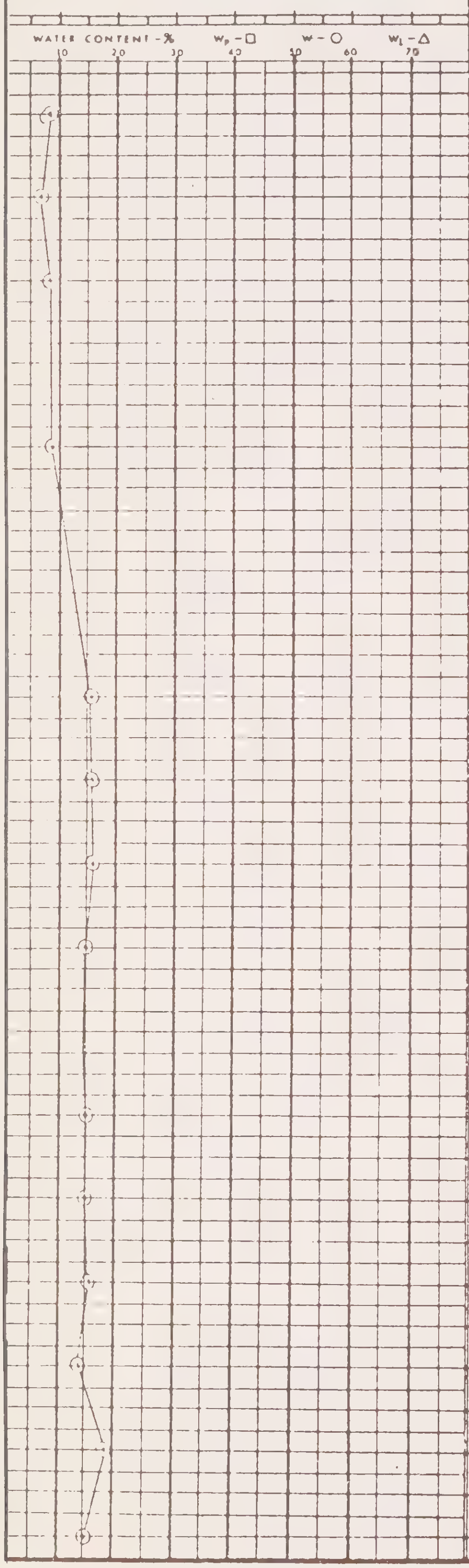
SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN | CKD | DATE OF INVESTIGATION | JOB NO E-2887 | HOLE 4

WATER CONTENT

WATER CONTENT - % | W_p - □ | W - ○ | W_L - △



DEPTH FEET	SOIL PROFILE — SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SYMBOL	UNIFIED CLASSIF.	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
36								
37	SILT, sandy, clayey low plastic		ML					
38	CLAY:							
39	silty, sandy							
40	pebbles to ½"							
41	dark grey med. plastic							
42								
43								
44	low plastic							
45								
46	hard							
47	med. plastic occas. pebbles to		Cl					
48	1/4" & 3/8"							
49								
50	dark brown							
51								
52	dark grey							
53								
54	med-high plastic							
55								
56								
57								
58	stiff,							
59	high plastic							
60	med. plastic							
61								
62								
63								
64	med-high plastic							
65								
66								
67								
68	high plastic							
69								
70								

PLATE 9

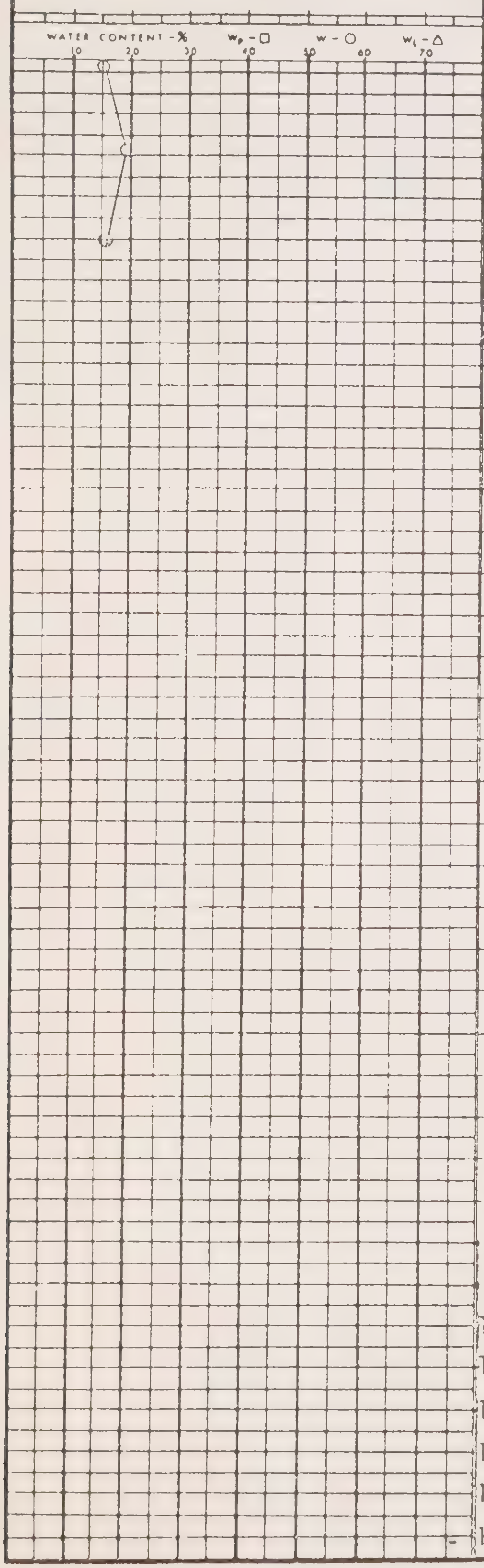
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT

DWN	CK'D	DATE OF INVESTIGATION	JOB NO	HOLE 4

WATER CONTENT



DEPTH FEET	SOIL PROFILE: SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SYMBOL	UNIFIED CLASSIF	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
71								
72								
73								
74								
75	END OF HOLE @ 74ft							
76								
77								
78								
79								
80								
81								
82								
83								
84								
85								
86								
87								
88								
89								
90								
91								
92								
93								
94								
95								
96								
97								
98								
99								
100								
101								
102								
103								
104								
105								

PLATE 10

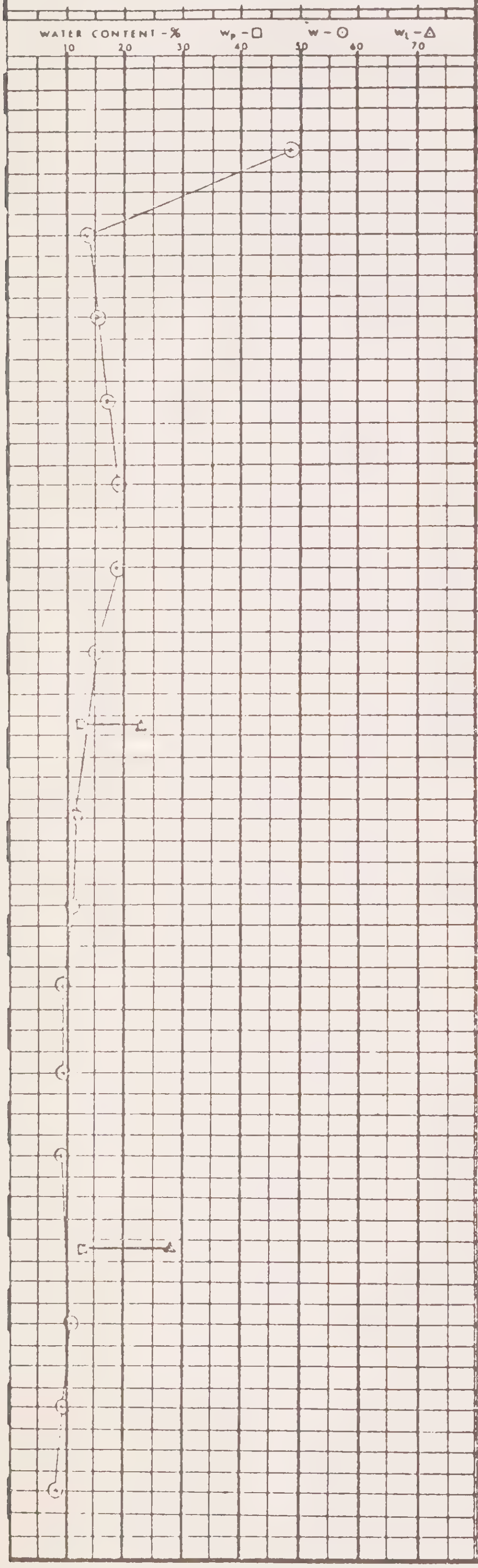
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J. FRANCL & ASSOCIATES TOWN EXPANSION NORMAN WELLS

DWN A.L. | CKD G. Mc. | DATE OF INVESTIGATION Mar 23/74 | JOB NO E-2887 | HOLE 5

WATER CONTENT



SOIL PROFILE — SOIL DESCRIPTION — DATUM — SURFACE ELEVATION

DEPTH FEET	SOIL DESCRIPTION	UNIFIED CLASSIF.
1–3	PEAT: trace of clay, black	Pt
4–18	CLAY (TILL): sandy, silty, med. plastic, brown, pebbles to ¼", calcareous (4–7); light brown (8); rust specks, pebbles to ½" (9); low to med. plastic (11); low plastic, gravelly (14)	CI
18–21	SILT: sandy, low plastic, dark grey	ML
21–35	CLAY: silty, sandy, low plastic (22–23); low-med plastic (24); low-med plastic, pebbles to ½" (25); low-med plastic, pebbles to ½" (27)	CI

SOIL SAMPLES: CONDITION | TYPE | PENETRATION RESISTANCE | RECOVERY % | OTHER TESTS

PLATE 11

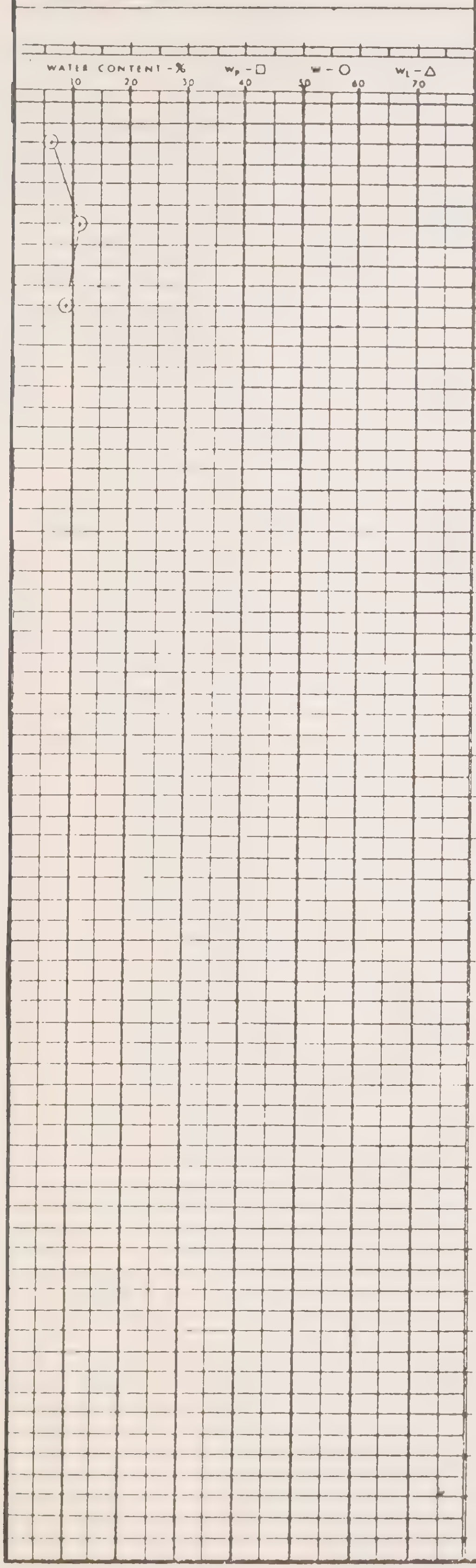
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J.FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN | CKD | DATE OF INVESTIGATION | JOB NO E-2887 | HOLE 5

WATER CONTENT



DEPTH FEET	SOIL PROFILE: SOIL DESCRIPTION (DATUM; SURFACE ELEVATION)	SOIL SYMBOL	UNIFIED CLASSIF	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
36	low-med.plastic							
37	odd pebbles to 3/4"							
38								
39								
40								
41	END OF HOLE @ 40 ft							
42								
43								
44								
45								
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								

PLATE 12

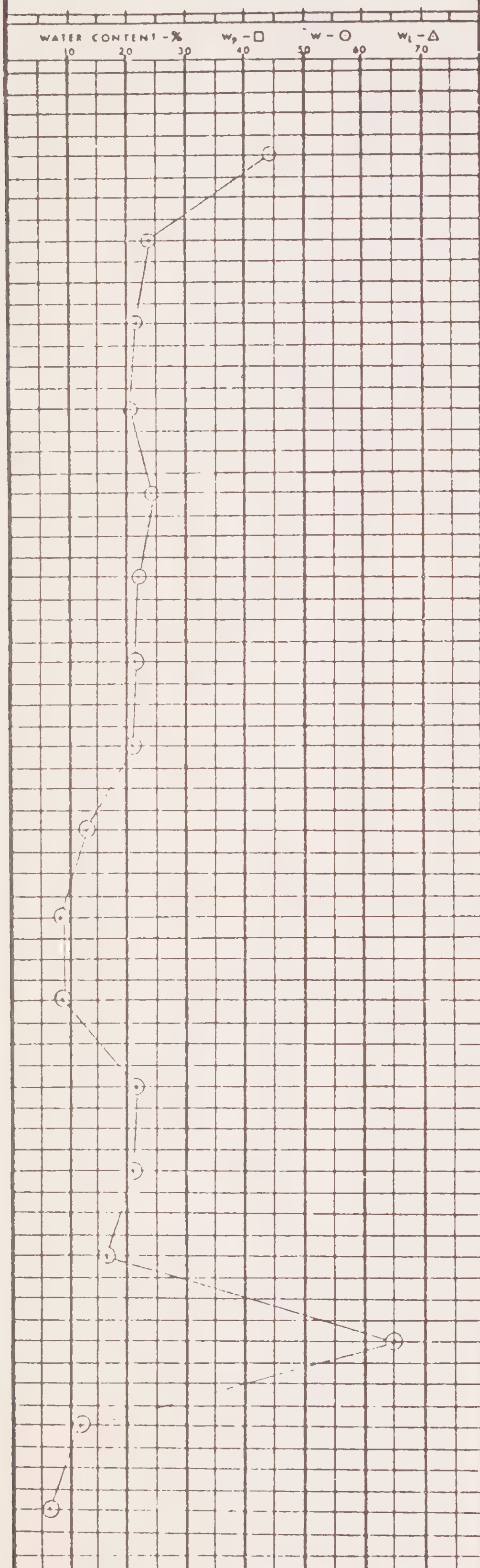
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN A.L. CKD G. Mc. DATE OF INVESTIGATION JOB NO E-2887 HOLE 6

WATER CONTENT



SOIL PROFILE — SOIL DESCRIPTION — DATUM — SURFACE ELEVATION — SOIL SYMBOL — UNIFIED CLASSIF.

SOIL SAMPLES — CONDITION — TYPE — PENETRATION RESISTANCE — RECOVERY % — OTHER TESTS

DEPTH FEET	SOIL DESCRIPTION	UNIFIED CLASSIF.
	Topsoil	
1	CLAY TILL	
	silty, sandy	
2	med. plastic	
3	odd pebbles to 3/4"	
	dark brown	
4		
5	med-high plastic	
6		
	med. plastic	
7		
8		
9		CI
10		
	odd pebbles to ½"	
11	SILT:	
12	sandy	
13	low plastic	
	light brown	
14	coal specks,	ML
15	rust spots	
16		
17		
18	SAND:	
19	silty, medium grain	
20	grey, pebbles to ½"	
21	pebbles to ¼"	
22		SM
23	fine grained	
24	pebbles to ½"	
25		
26	CLAY:	
27	silty, sandy	
28	med. plastic	
	dark grey	
29		CI
30	SAND:	
31	silty, clayey	
32	course grained	SC
33	pebbles to ½"	
34	GRAVEL, sandy	
35	pebbles to 3/4"	GW

PLATE 13

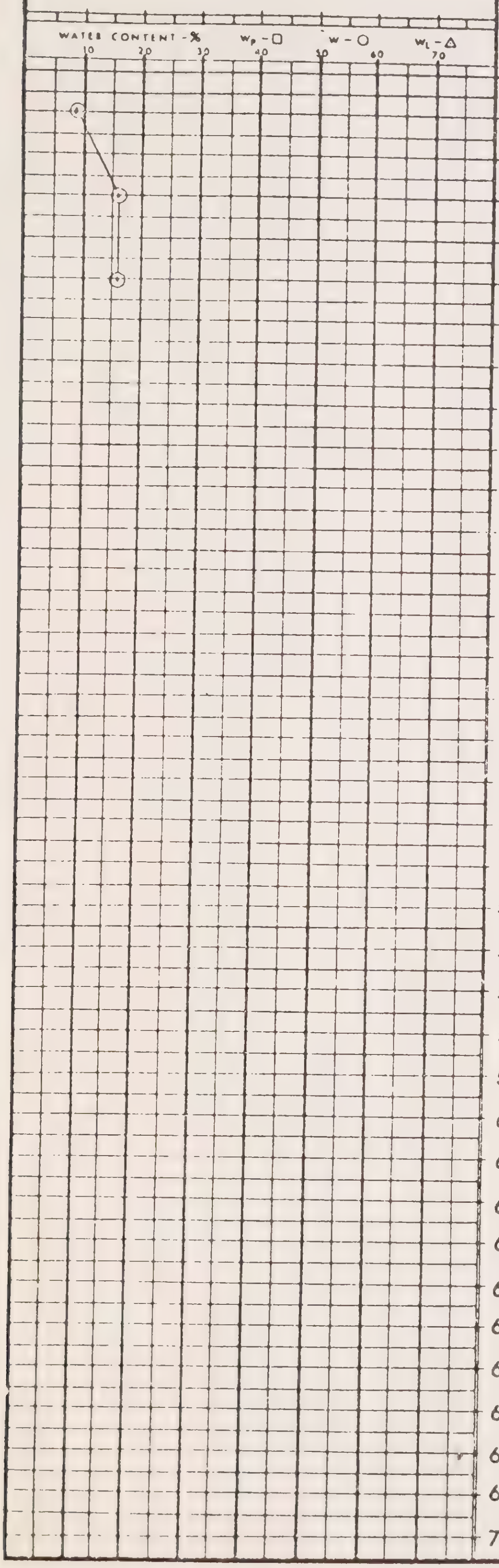
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN	CKD	DATE OF INVESTIGATION	JOB NO E-2887	HOLE 6

WATER CONTENT



SOIL PROFILE

DEPTH FEET	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SYMBOL	UNIFIED CLASSIF	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
36–38	SAND: silty, grey pebbles to ¼"		SM					
38–40	CLAY: silty, sandy med-high plastic		CI					
40	END OF HOLE @ 40 ft							

Depth scale: 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70

PLATE 14

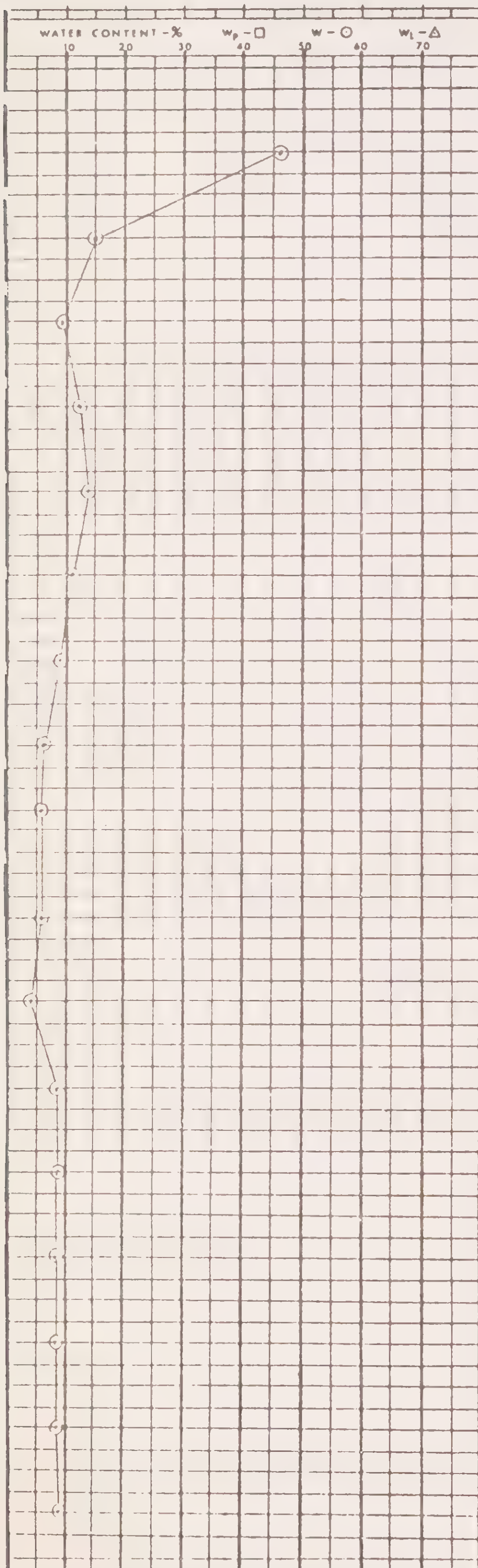
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN A.L. | CKD G. Mc | DATE OF INVESTIGATION Mar 25/74 | JOB NO E-2887 | HOLE 7

WATER CONTENT



SOIL PROFILE

DEPTH FEET	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	UNIFIED CLASSIF.	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
0 – 3	PEAT: trace of silt, rootlets	Pt					
3 – 12	CLAY (TILL): silty, sandy, med. plastic, light brown; low to med plastic, pebbles to ½", brown, rust specks; low plastic	CI					
12 – 14	SAND, silty fine to med grained, brown, pebbles to ½"	SM					
14 – 16	GRAVEL, sandy, silty, pebbles to 3/4", brown	GM					
16 – 18	SAND, gravelly, silty, well graded, brown	SW					
18 – 26	GRAVEL, very sandy, silty, brown, pebbles to 3/4"; well graded	GW					
26 – 35	CLAY: sandy, silty, med. plastic, dark grey, pebbles to 3/4"; pebbles to ½"; high plastic	CI					

PLATE 15

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN: A.L. | CKD: G. Mc. | DATE OF INVESTIGATION: Mar 25/74 | JOB NO: E-2887 | HOLE: 7

WATER CONTENT

WATER CONTENT - % 10 20 30 40 50 60 70 | w_p - □ | w - ⊙ | w_L - △

DEPTH FEET	SOIL PROFILE — SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SYMBOL	UNIFIED CLASSIF.	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
36	pebbles to ¼"							
37								
38	med. to high plastic							
39	coal specks							
40	rust spots							
41	END OF HOLE @ 40 ft							
42								
43								
44								
45								
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								

PLATE 16

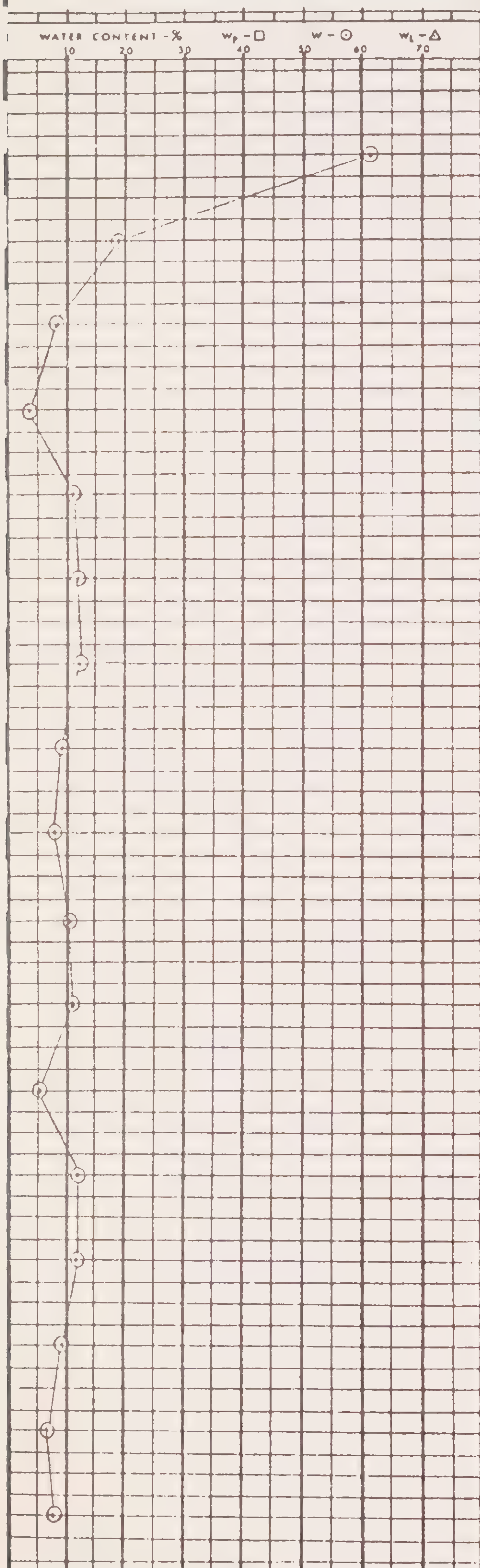
R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT: W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN: A.L. | CKD: G. Mc. | DATE OF INVESTIGATION: Mar 25/74 | JOB NO: E-2887 | HOLE: 8

WATER CONTENT



DEPTH FEET	SOIL PROFILE — SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	UNIFIED CLASSIF.	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
0–3	PEAT: trace of clay, black	Pt					
3–6	CLAY (TILL): sandy, silty, med.plastic, brown	CI					
6–10	SAND: silty, pebbles to ¼", brown; fine-med grained	SM					
10–30	CLAY: sandy, silty, low plastic, brown, pebbles to ¼", coal specks, rust spots; (15) low to med.plastic; (17) med.plastic, dark grey; (18) med to high plastic, coal specks, rust spots; (26) pebbles to ½"; (28) pebbles to ¼"	CL					
30–35	SAND: silty, med. grained, dark grey, pebbles to ¼"; (34) coarse grained, pebbles to ½"	SM					

Depth (feet): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35

PLATE 17

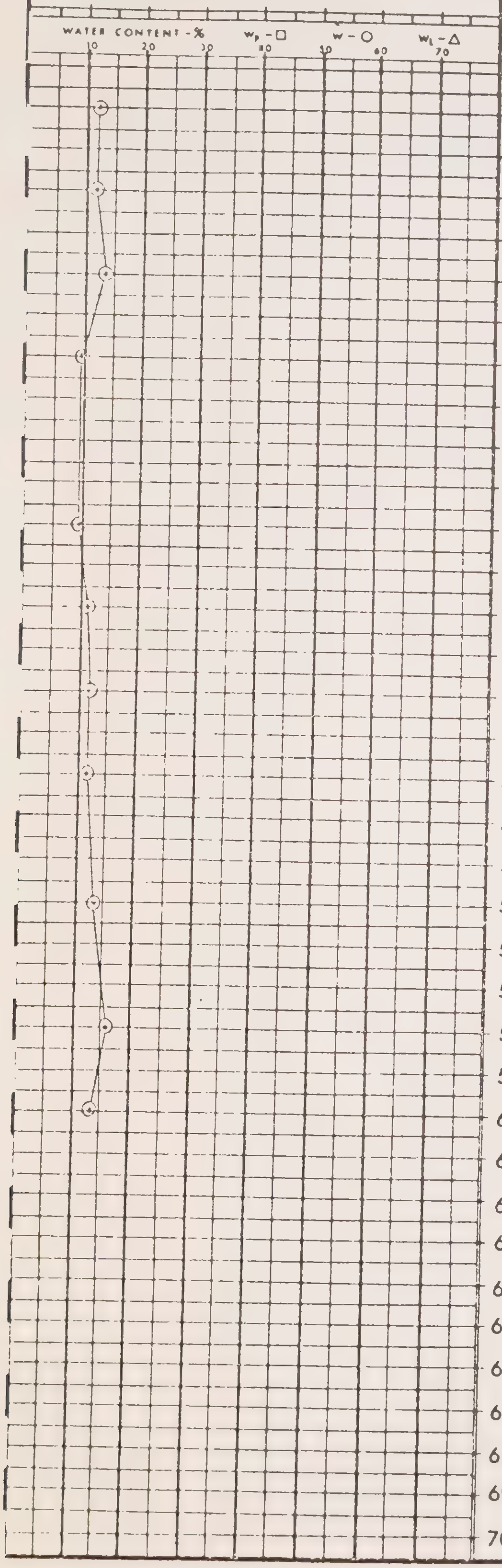
R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

SUMMARY OF SAMPLING & LABORATORY TESTS

PROJECT W.J. FRANCL & ASSOCIATES
TOWN EXPANSION NORMAN WELLS

DWN | CKD | DATE OF INVESTIGATION | JOB NO E-2887 | HOLE 8

WATER CONTENT



SOIL PROFILE — SOIL DESCRIPTION — SOIL SAMPLES

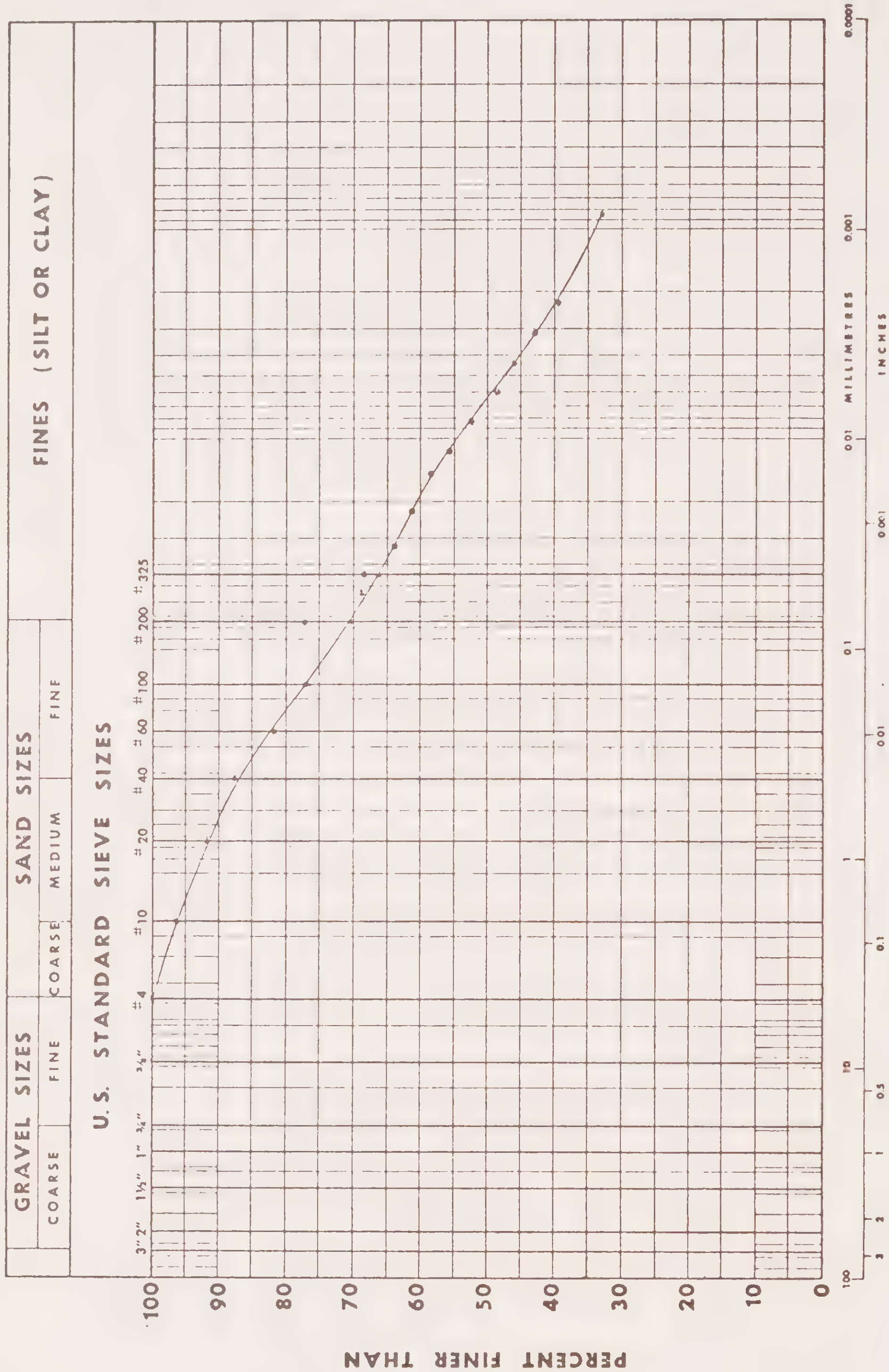
DEPTH FEET	DATUM / SURFACE ELEVATION	SOIL SYMBOL	UNIFIED CLASSIF.	CONDITION	TYPE	PENETRATION RESISTANCE	RECOVERY %	OTHER TESTS
36								
37								
38	trace of silt							
39								
40	med grained, brown							
41	coal specks, shale inclusions,							
42	course grained							
43								
44								
45			SM					MA see Plate 21
46	dark grey							
47								
48	med to coarse grained							
49								
50								
51								
52								
53								
54	dark brown							
55	coal specks							MA see Plate 22
56	shale inclusions pebbles to ½"							
57	fine-med. grained							
58	fine grained							
59								
60	END OF HOLE @ 60 ft							
61								
62								
63								
64								
65								
66								
67								
68								
69								
70								

PLATE 18

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	E 2887 - S 1399
CLIENT	
SAMPLE	
SOURCE	
HOLE 1	DEPTH 24' DATE REC'D.
TECHNICIAN O.R.	DATE TESTED APRIL 19/7



D_{10} = ___ MM.
D_{30} = ___ MM.
D_{60} = ___ MM.
C_u ___
C_c ___

REMARKS: ESTIMATED SPECIFIC GRAVITY

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE 19

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	[illegible] 2887 - [illegible]
CLIENT	
SAMPLE	
SOURCE	
HOLE 2 DEPTH 14'	DATE REC'D.
TECHNICIAN [illegible]	DATE TESTED [illegible]

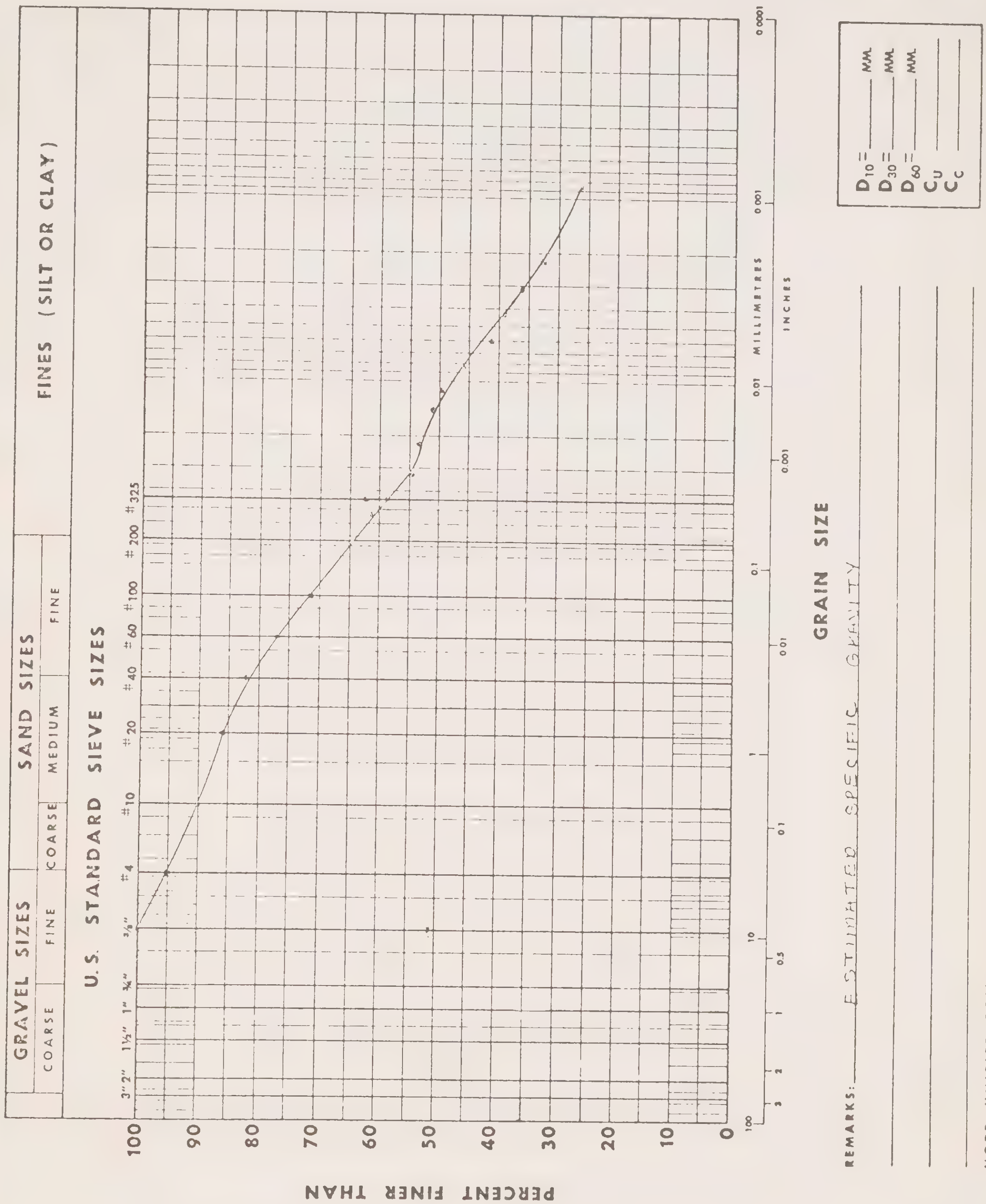
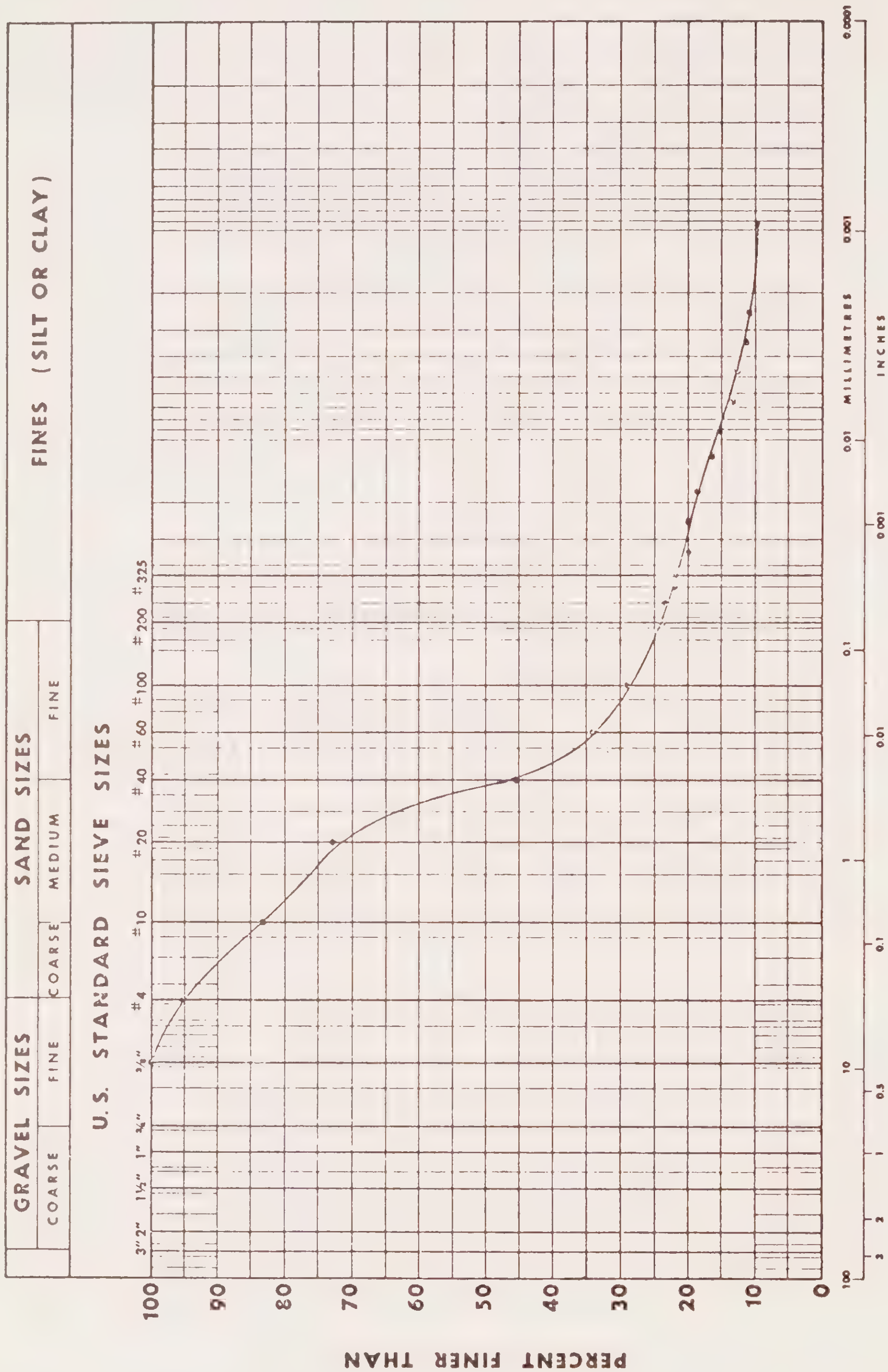


PLATE 20

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.	E 2887 - S1395
CLIENT	
SAMPLE	
SOURCE	
HOLE 8 DEPTH 44'	DATE REC'D.
TECHNICIAN O.R	DATE TESTED April 19/74



D_{10} = ____ MM.
D_{30} = ____ MM.
D_{60} = ____ MM.
C_U ____
C_C ____

REMARKS: ESTIMATED SPECIFIC GRAVITY

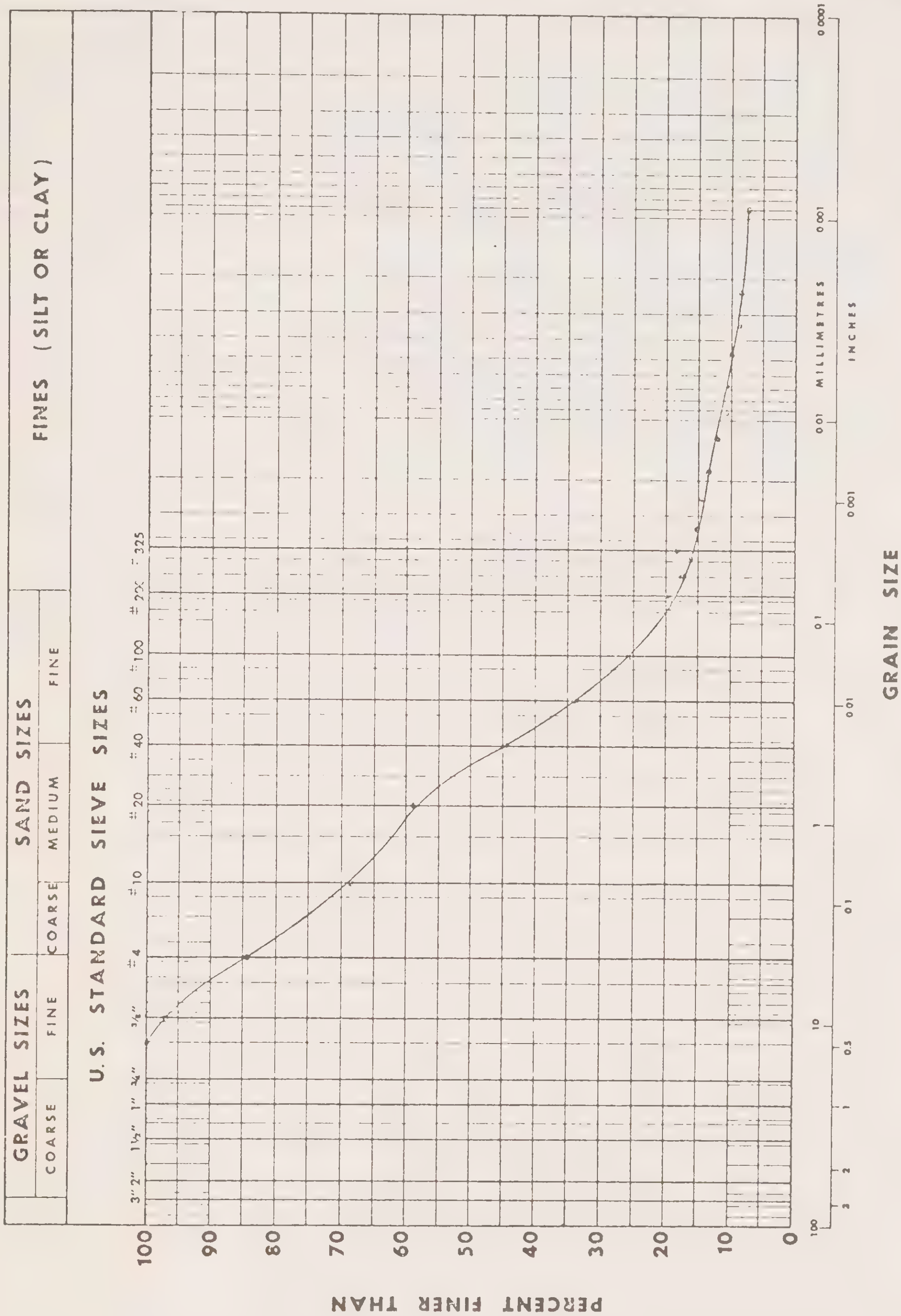
NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE 21

R.M. HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

GRAIN SIZE CURVE

LAB ORDER NO.			
CLIENT			
SAMPLE			
SOURCE			
HOLE 8	DEPTH 54'	DATE REC'D.	
TECHNICIAN		DATE TESTED	



D_{10} = ____ MM.
D_{30} = ____ MM.
D_{60} = ____ MM.
C_U = ____
C_C = ____

REMARKS: ESTIMATED SPECIFIC GRAVITY

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE 22

LAND USE AND DEVELOPMENT CONTROLS

Recommendations and proposals for the future development of Norman Wells were presented in the main report. Those proposals included the development of the existing site and/or the development of a new townsite, both encompassing a full range of urban uses. The scale and nature of development are large and wide enough to necessitate relatively strict control of development to ensure that the community is built up in the most orderly and economical manner to the benefit of its residents. To achieve this control, we recommend the establishment of zoning and development controls following the adoption of one or other alternative for development. As a guide to Council and the admininstration for the implementation of such controls, presented here are propo sals for land use designations, standards and zoning.

The Design Concept Plans established the extent and areas of the following land use categories:

a) residential
b) commercial
c) public and semi-public
d) recreational
e) industrial
f) highway services.

The following proposals or regulations forming the basis of the proposed bylaw should apply to development within those various categories or zones.

A. Residential

In order to provide adequate housing and prevent overcrowding the size of new buildings when allocated should be related to the family size. The dwellings should provide adequate storage areas and spacious porches, front and rear, to reduce

the impact of wind and low outside temperatures. They should provide adequate working area, heat and light; and should have provision for eventual, if not immediate, connection to piped utilities. Meanwhile sufficient and hygienic indoor water storage and toilet facilities should be provided. In order to give proper separation of buildings for privacy and fire protection each single-family house should be located on its own properly defined lot. The lot should be kept in a clean condition to prevent ground contamination and to enhance the physical appearance of the community. Within the residential area land may only be used for the following purposes:

1) Single-family dwelling.
2) Single persons' accommodation.
3) Auxiliary buildings related to the occupational pursuits of the residents including small warehouses, workshops, storage sheds and garages. None of these buildings should be located in front yards and all should conform to fire regulations.
4) Utility installation and facilities necessary for the residential use.
5) Mobile homes and multiple housing accommodation if approved for location and siting by the planning authorities of the Government of the Northwest Territories and the local Council.

To allow for the protection of safety and privacy of adjacent residents and other developments each residential building shall have:

1) Minimum front yard of not less than 15 feet.

2) A rear yard of at least 20 feet, unless otherwise required for installation of utilities and approved by Territorial Fire Marshal.
3) Side yards and separation between buildings as established by the Territorial Fire Marshal.

B. Commercial

Land in the commercial area may be used only for the following:

1) Retail stores.
2) Service-types of commercial development.
3) Residence, warehouse and storage servicing related to permitted commercial development.
4) Public utility installation.
5) Such other commercial development as will not cause fire hazards, nuisance, or impose unsightly conditions upon adjacent residence.

The standards of development applicable in the commercial area would be:

1) Each commercial building may be built to the front properly line.
2) Each commercial building shall be at least 20 feet distant from the rear property line unless otherwise conditioned by provision of utilities and authorized by the Territorial Fire Marshal.
3) Side yards shall be provided in accordance with fire regulations.
4) Any indoor and outdoor storage of goods and materials must provide for adequate fire separation and shall be carried out in an orderly manner.
5) No storage or handling of materials and/or goods which

by reason of excessive odor, dust or other nuisance could adversely affect residential comfort shall be allowed unless in a manner which would eliminate or minimize the adverse effects.

C. Public and Semi-Public

Land in the public and semi-public areas may only be used for:

1) Administrative and community buildings.
2) Educational buildings.
3) Health buildings and facilities.
4) Churches, hostels and similar facilities.
5) Public utility installations.
6) Living quarters, whether a part of or separate from the main building.
7) Auxiliary buildings related to the above uses but which are not of an industrial nature.

All buildings in this land use category shall conform to the minimum set-backs and yards at the standard and depth applicable to residential development. All auxiliary buildings shall conform to the same set-backs and yards applicable to the main building. All outdoor storage shall be kept in an orderly manner.

D. Recreational

Land in the recreational or park areas shall be used only for:

1) Sports field.
2) Playground.
3) Park.
4) Public sports and recreational buildings and facilities.

Only sports and recreational equipment and facilities shall be allowed in the park and recreational area. No storage of materials, whether public or private shall be allowed nor should buildings be erected unless part of the recreational facility.

E. Light Industrial

Land in the light industrial area may be used only for the following:

1) Public utilities and plant.
2) Warehousing and light manufacturing.
3) Repair establishments.
4) Wholesale storage.
5) Yards and enclosures for equipment and material storage.
6) Docks and landing strips.
7) Auxiliary buildings related to primary use.
8) Such other development as, according to the judgement of the Council and administration is of a similar nature to the above.

All buildings in this land use category shall have a minimum set-back or yard of the standard and depth applicable to commercial development. All auxiliary buildings shall conform to the same set-backs and yards as applicable to the main building. Outdoor storage shall be placed in such a manner that it does not obstruct access to the rear of lots. Safety measures, building set-backs, etc. shall be strictly enforced with regard to fire hazards. The appearance of buildings and outdoor storage shall be well-maintained and should not be

allowed to become unsightly. No industrial development which creates a considerable nuisance (odor, noise, smoke, etc.) shall be permitted in a location where it could adversely affect adjoining developments.

F. Highway Service Area

Land in the highway service area shall be used only for those uses serving the travelling public and/or highway maintenance and including the following:

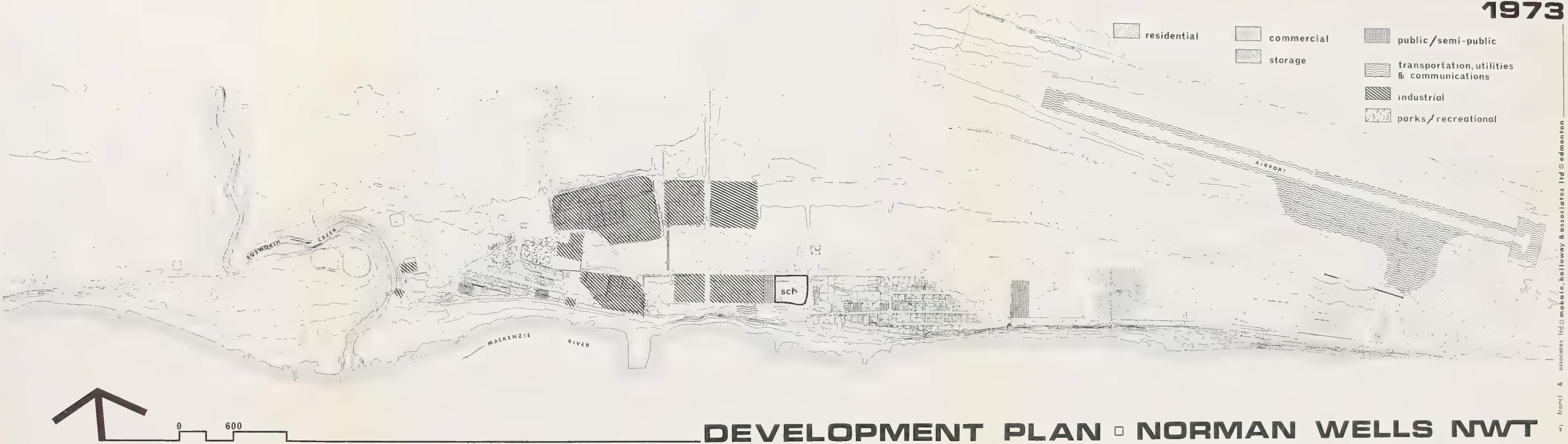
1) Hotels, motels and other drive-in establishments.
2) Highway maintenance yards.
3) Trucking establishments.
4) Storage areas related to highway maintenance and operation.
5) Service stations and automotive servicing establishments.
6) Public utility installations.

The standards of development shall be similar to those applicable in the commercial and instrial areas.

APPENDIX "I"

LAND USE AND DEVELOPMENT CONTROLS

land use 1973

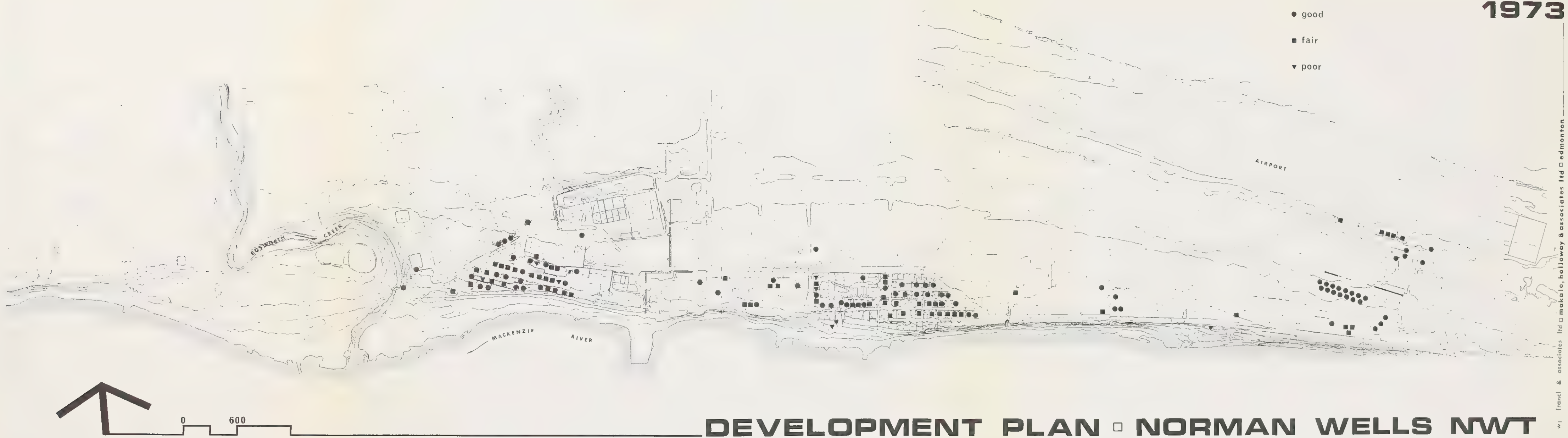


DEVELOPMENT PLAN □ NORMAN WELLS NWT

PLATE I

wj francl & assocates ltd □ makale, holloway & associates ltd □ edmonton

building conditions 1973



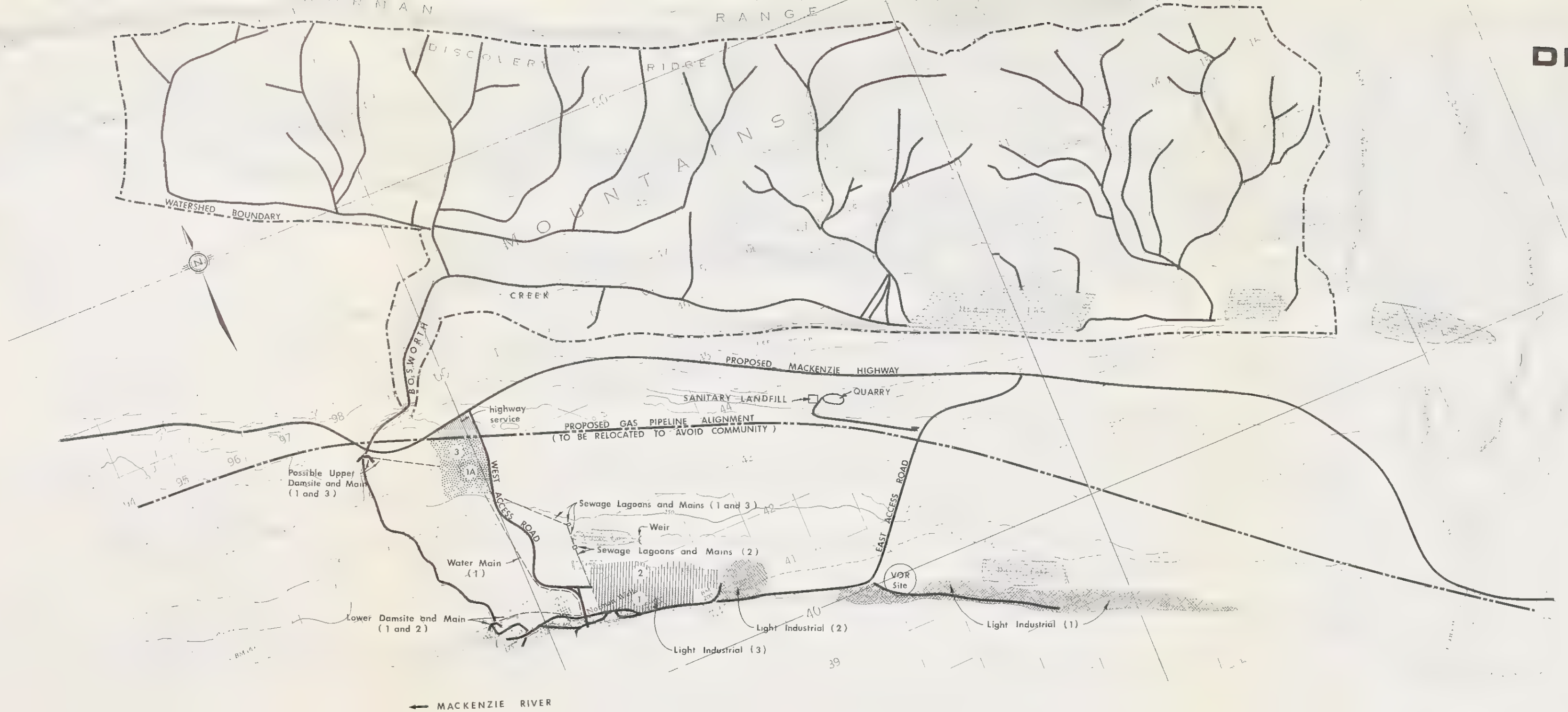
DEVELOPMENT PLAN □ NORMAN WELLS NWT

PLATE 2

w l francl & associates ltd □ makale, holloway & associates ltd □ edmonton

DEVELOPMENT PLAN
NORMAN WELLS

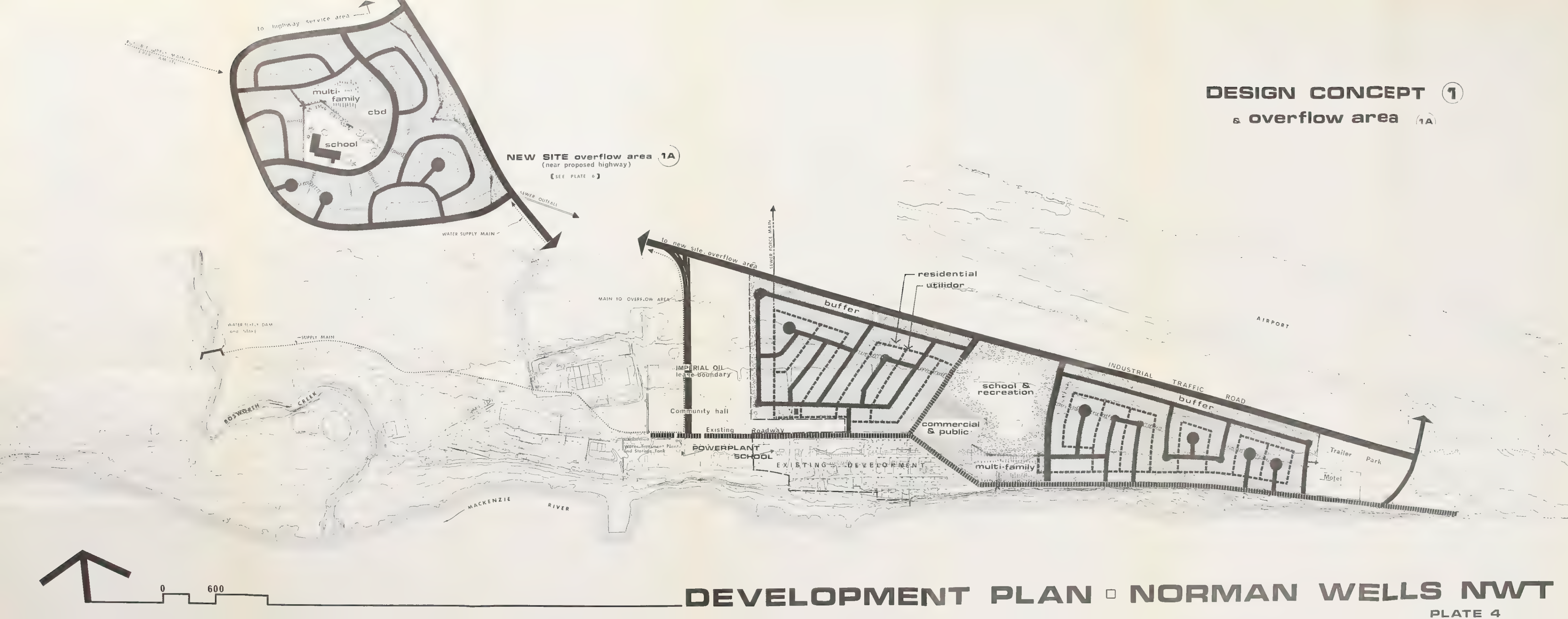
alternative locations of future community



FEET 0 5000 10,000 15,000

(1) (2) (3) : DESIGN CONCEPTS 1, 2 and 3.

PLATE 3

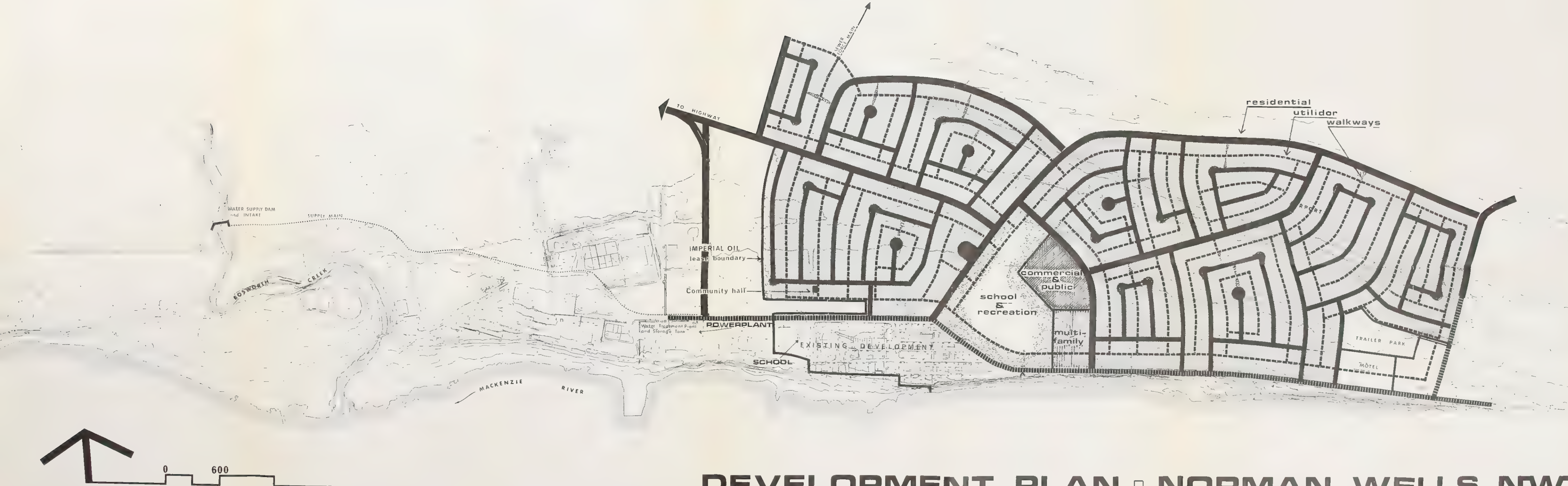


DEVELOPMENT PLAN ▫ NORMAN WELLS NWT

PLATE 4

wj francl & associates ltd ▫ makale, holloway & associates ltd ▫ edmonton

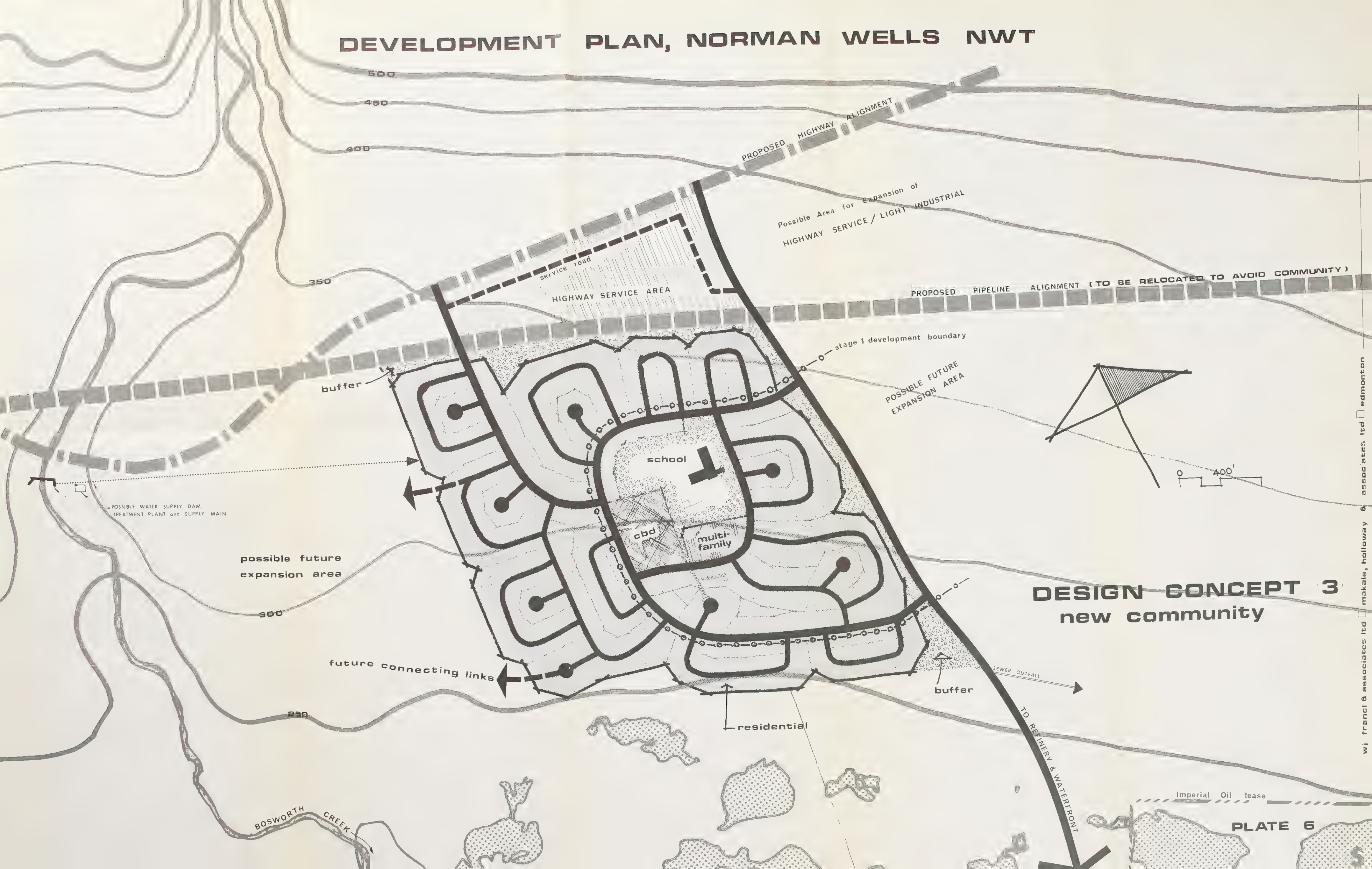
DESIGN CONCEPT 2



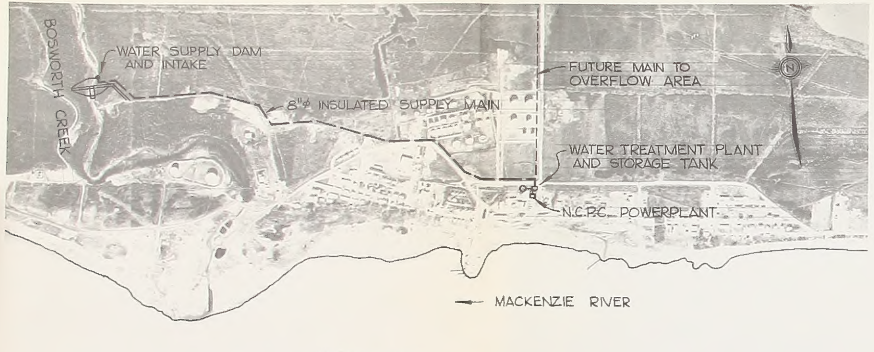
DEVELOPMENT PLAN ▫ NORMAN WELLS NWT

PLATE 5

wj francl & associates ltd ▫ makale, holloway & associates ltd ▫ edmonton


DEVELOPMENT PLAN, NORMAN WELLS NWT
500
450
400
350
300
250
PROPOSED HIGHWAY ALIGNMENT
Possible Area for Expansion of HIGHWAY SERVICE / LIGHT INDUSTRIAL
service road
HIGHWAY SERVICE AREA
PROPOSED PIPELINE ALIGNMENT (TO BE RELOCATED TO AVOID COMMUNITY)
stage 1 development boundary
POSSIBLE FUTURE EXPANSION AREA
buffer
school
cbd
multi-family
POSSIBLE WATER SUPPLY DAM, TREATMENT PLANT and SUPPLY MAIN
possible future expansion area
future connecting links
residential
buffer
SEWER OUTFALL
TO REFINERY & WATERFRONT
0 400'
DESIGN CONCEPT 3
new community
Imperial Oil lease
BOSWORTH CREEK
PLATE 6
wj francl & associates ltd □ makale, holloway & associates ltd □ edmonton

WATER SUPPLY ▫ DESIGN CONCEPTS 1 & 2



OVERALL PLAN

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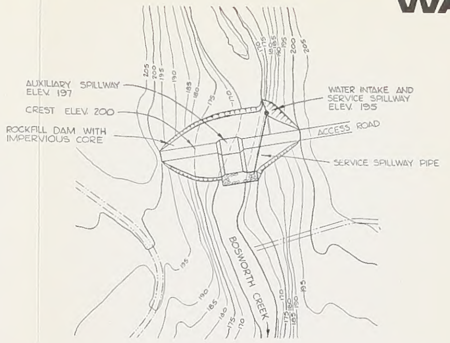

DAM SITE

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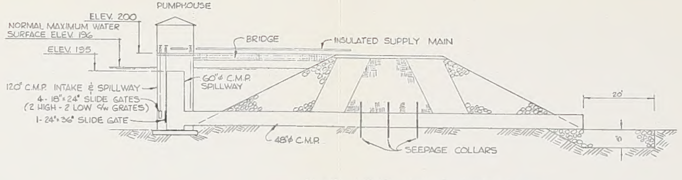

WATER INTAKE AND SERVICE SPILLWAY

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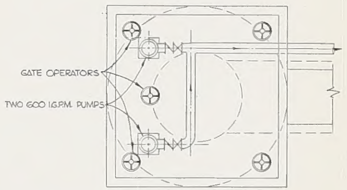
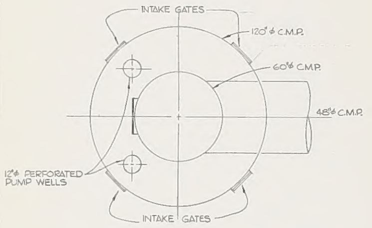


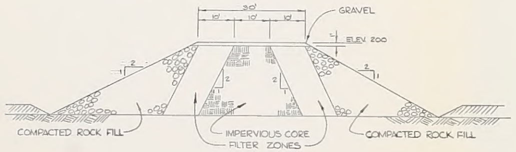
PUMP FLOOR PLAN

FEET 0 1 2 3 4 5



LOWER LEVEL PLAN

FEET 0 1 2 3 4 5



TYPICAL SECTION

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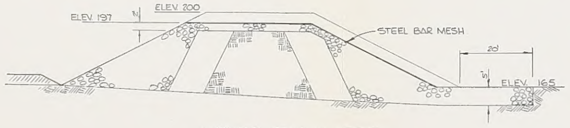

AUXILIARY SPILLWAY SECTION

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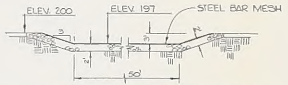

AUXILIARY SPILLWAY - CREST PROFILE

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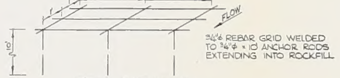

STEEL BAR MESH

DEVELOPMENT PLAN ▫ NORMAN WELLS NWT

w.l. francl and associates ltd

PLATE 7